# FINAL FIELD SAMPLING PLAN EASTERN PLUME — OPERABLE UNIT 1

NEW CASSEL/HICKSVILLE GROUNDWATER CONTAMINATION SUPERFUND SITE NASSAU COUNTY, NEW YORK

U.S. EPA Site No. NY0001095363

Revision: 0

EnSafe Project Number: 0888820265

Prepared for:

101 Frost Street Associates, L.P. and Next Millennium Realty, LLC

April 2022

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# **APPENDICES**

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EnSafe Standard Operating Procedures

### **ACRONYMS**

ASTM American Society for Testing and Materials

bgs below ground surface

FSP Field Sampling Plan

NCDPW Nassau County Department of Public Works

NCIA New Cassel Industrial Area NTU nephelometric turbidity units

NYSDEC New York State Department of Environmental Conservation

ORP Oxidation Reduction Potential

OU operable unit

PPE Personal Protective Equipment

PVC Polyvinyl Chloride

QAPP Quality Assurance Project Plan

ROD Record of Decision

SOP Standard Operating Procedure

TBD to be determined

μg/L micrograms per liter UGA Upper Glacial Aquifer

USDOT United States Department of Transportation
U.S. EPA United States Environmental Protection Agency

VOC volatile organic compound



# 1.0 INTRODUCTION

On behalf of 101 Frost Street Associates, L.P. and Next Millennium Realty LLC, EnSafe Inc. has prepared this Field Sampling Plan (FSP) for the pre-design investigation for the Eastern Plume of Operable Unit (OU) 1 of the New Cassel/Hicksville Groundwater Contamination Superfund Site (Site), located in Nassau County, New York. The remedy for OU1 was selected in the OU1 Record of Decision (ROD) issued by the United States Environmental Protection Agency (U.S. EPA) on September 30, 2013.

### 1.1 Purpose

This FSP was prepared to provide the applicable procedures for field activities related to groundwater analytical sampling during the pre-design investigation (U.S. EPA, May 2017). Additional documents have been prepared for the Eastern Plume under separate cover that are intended to accompany this FSP:

- Quality Assurance Project Plan (QAPP): Accompanies this FSP and describes quality assurance/quality control measures, sample analysis and data handling requirements, chain of custody procedures, and project data objectives.
- Site Management Plan: Includes the Institutional Control Implementation Assurance Plan, Transportation and Offsite Disposal Plan, Quality of Life Plan, and the Monitoring Plan for operation and maintenance of the Site remedy.
- Health and Safety Plan with Emergency Response Plan: Details Site-specific health and safety requirements and procedures to be used in the event of an accident, spill, or emergency at the Site including responsible parties, community meetings, notification requirements, and compliance requirements.

### 1.2 Project Organization

Key project personnel are summarized in Table 1.

Table 1 Key Project Personnel				
Title	Name	Contact Information		
U.S. EPA Project Manager	Julio Vazquez	vazquez.julio@epa.gov 212-637-4323		
U.S. EPA Quality Assurance Officer	To be determined	To be determined		
EnSafe Project Manager	Alexandra Stark	astark@ensafe.com 860-920-5172		
EnSafe Quality Assurance Officer	To be determined	To be determined		
EnSafe Field Team Leader	To be determined	To be determined		





### **Notes:**

Laboratory personnel and information can be found in the Quality Assurance Project Plan. U.S. EPA = United States Environmental Protection Agency



### 2.0 BACKGROUND

### 2.1 Site Description and Background

The Site comprises a widespread area of groundwater contamination within the Town of North Hempstead, Town of Hempstead, and the Town of Oyster Bay, all of which are located in Nassau County, New York (Figure 1). The Site is approximately 6.5 square miles. The Site was listed on the National Priorities List in 2011.

The Site's OU1 is a discrete portion of contaminated groundwater downgradient of the New Cassel Industrial Area (NCIA) located within the Towns of North Hempstead and Hempstead. OU1 is located primarily in Salisbury, an unincorporated area of the Town of Hempstead, and the portion of OU1 north of Grand Boulevard is located within the Hamlet of New Cassel, in the Town of North Hempstead (Figure 2). OU1 is approximately 211 acres and consists of residential properties, as well as some commercial areas.

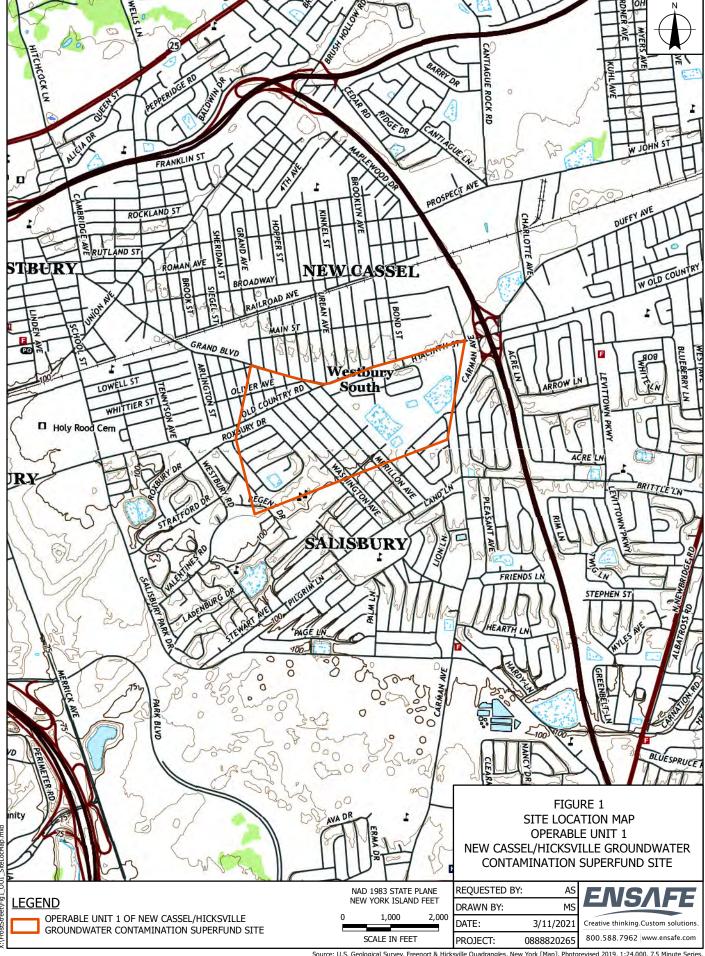
Upgradient of OU1 is the NCIA, which is currently being managed by the New York State Department of Environmental Conservation. The NCIA encompasses approximately 170 acres and is bounded by the Long Island Railroad to the north, Frost Street to the east, Old Country Road to the south, and Grand Boulevard to the southwest.

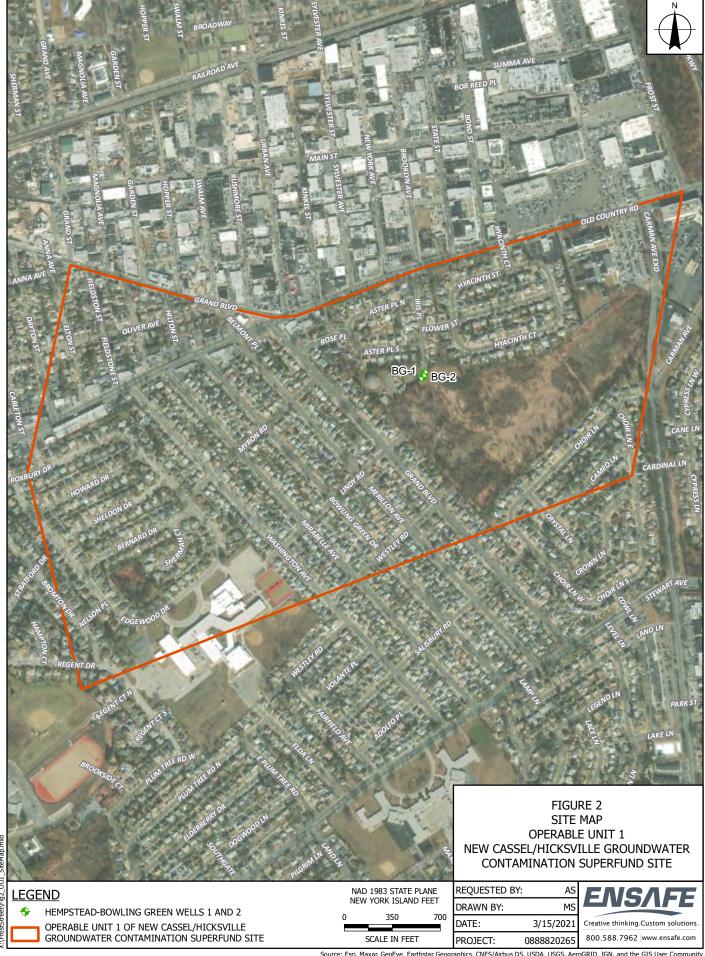
The Town of Hempstead's Bowling Green Water District operates Wells 1 and 2 on property that is located within OU1 (labeled as Hempstead-Bowling Green Wells 1 and 2, on Figure 2). The Bowling Green Water District has been treating groundwater pumped from these two wells since 1990, when a granular activated carbon system was installed. Five years later, the treatment system was supplemented with an air stripper. The Town of Hempstead previously maintained monitoring and treatment activities to address volatile organic compound (VOC) contamination prior to its distribution to the drinking water system, however, these wells are not currently operational.

### 2.2 Site Geology/Hydrogeology

The principal hydrogeologic units underlying OU1 are the glacial outwash and morainal deposits known as the Upper Glacial Aquifer (UGA) and the underlying Magothy Formation and Matawan Group (Magothy). Beneath these two units are the clay member and the Lloyd Sand member of the Raritan Formation.

The UGA is estimated to be 60 to 80 feet thick and consists predominantly of coarse-grained sands and gravels. A distinct transition between the UGA and the Magothy units has not been observed in the OU1 area. The underlying Magothy Formation sediments (estimated to be approximately 600 feet thick) are characterized by sand and silty sand with discontinuous clay and silt layers. Geologic







studies in the area have revealed that sediments tend to become finer in size fraction downward in the Magothy Formation, except within the basal portion where coarse-grained sands and gravels are prevalent.

Unconfined groundwater is generally found at the Site between 38 to 50 feet below ground surface (bgs). Groundwater within the UGA and Magothy aquifers flows in a south-southwest direction in the area downgradient of the NCIA. There is a natural downward vertical gradient across OU1 that is enhanced by the pumping of the Bowling Green Water District supply wells. Pumping of the Bowling Green Water District water supply wells also may influence the groundwater flow direction above the depth of their production interval, which is approximately 470 to 580 feet bgs.

### 2.3 Nature of Groundwater Contamination

The Site has been characterized by VOC contaminated groundwater that has impacted several water supply wells, including four Town of Hempstead municipal wells, six Hicksville water supply wells, and one Village of Westbury water supply well. Analytical results of groundwater samples from the Site have revealed three groundwater plumes with concentrations of VOCs in excess of the U.S. EPA's promulgated health-based protective maximum contaminant levels and New York State's standards. OU1 has three plumes, the Western Plume, the Central Plume, and the Eastern Plume, each with different source areas and contamination chemical compositions.

At the time of data collection for the OU1 ROD (2011), the Eastern Plume, subject of this FSP, was comprised predominantly of tetrachloroethene up to 16,000 micrograms per liter ( $\mu$ g/L) with some trichloroethene and concentrations less than 23  $\mu$ g/L of 1,1,1-trichloroethane. Contamination appears to migrate deeper as the distance along the plume axis increases away from the NCIA. Subsequent groundwater sampling events indicate the since 2011 Eastern Plume groundwater concentrations have decreased at all OU1 wells except MW-17D, located in the southern portion of OU1.



# 3.0 SAMPLING DESIGN AND RATIONALE

# 3.1 Contaminants of Concern

Contaminants of concern for the Site and their associated action levels are presented in Table 2.

Table 2					
Contaminant	Contaminants of C NYSDEC Water Quality Standards (µg/L)	Oncern U.S. EPA Maximum Contaminant Level (µg/L)	Selected Criteria (µg/L)		
Dichlorodifluoromethane	5	NS	5		
Chloromethane	NS	NS	NS		
Vinyl chloride	2	2	2		
Bromomethane	5	NS	5		
Chloroethane	5	NS	5		
Trichlorofluoromethane	5	NS	5		
1,1-Dichloroethene	5	7	5		
1,1,2-Trichloro-1,2,2-trifluoroethane	5	NS	5		
Acetone	NS	NS	NS		
Carbon disulfide	60	NS	60		
Methyl acetate	NS	NS	NS		
Methylene chloride	5	5	5		
trans-1,2-Dichloroethene	5	100	5		
Methyl tert-butyl ether	NS	NS	NS		
1,1-Dichloroethane	5	NS	5		
cis-1,2-Dichloroethene	5	70	5		
2-Butanone (MEK)	NS	NS	NS		
Chloroform	7	80	7		
1,1,1-Trichloroethane	5	200	5		
Cyclohexane	NS	NS	NS		
Carbon tetrachloride	5	5	5		
Benzene	1	5	1		
1,2-Dichloroethane	0.6	5	0.6		
Trichloroethene	5	5	5		
Methylcyclohexane	NS	NS	NS		
Bromodichloromethane	5	80	5		
1,2-Dichloropropane	1	5	1		
Toluene	5	1000	5		
trans-1,3-Dichloropropene	0.4	NS	0.4		
cis-1,3-Dichloropropene	NS	NS	NS		
4-Methyl-2-pentanone	NS	NS	NS		
1,1,2-Trichloroethane	1	5	1		
Tetrachloroethene	5	5	5		



Table 2 Contaminants of Concern				
Contaminant	NYSDEC Water Quality Standards (µg/L)	U.S. EPA Maximum Contaminant Level (µg/L)	Selected Criteria (µg/L)	
2-Hexanone	NS	NS	NS	
Dibromochloromethane	NS	80	80	
1,2-Dibromoethane	NS	500	500	
Chlorobenzene	5	100	5	
Ethylbenzene	5	700	5	
Xylenes (total)	5	NS	5	
Styrene	5	100	5	
Bromoform	NS	80	80	
Isopropylbenzene	5	NS	5	
1,1,2,2-Tetrachloroethane	5	NS	5	
1,3-Dichlorobenzene	5	NS	5	
1,4-Dichlorobenzene	5	75	5	
1,2-Dichlorobenzene	5	600	5	
1,2-Dibromo-3-chloropropane	0.04	20	0.04	
1,2,4-Trichlorobenzene	5	70	5	
1,4-Dioxane	NS	NS	NS	

#### Notes:

NYSDEC = New York State Department of Environmental Conservation

U.S. EPA = United States Environmental Protection Agency

VOC = volatile organic compound µg/L = micrograms per liter

# 3.2 Additional Analytes

Per the PDI Work Plan (U.S. EPA, May 2017), a minimum of 30% of the groundwater samples collected from permanent monitoring wells will also be analyzed for ferrous iron (Standard Method [SM]3500-Fe D), dissolved and total metals (U.S. EPA Method 6010), total hardness (SM2340B), and alkalinity (test kit or SM2320B) to support pilot testing. The Target Analyte List for metals is: aluminum, antimony, arsenic, barium, beryllium, boron, cadmium, calcium, chromium, cobalt, copper, iron, lead, magnesium, manganese, molybdenum, nickel, potassium, selenium, silver, sodium, strontium, thallium, tin, vanadium, and zinc. U.S. EPA will be performing this portion of the sampling.

# 3.3 Groundwater Sampling

Groundwater samples will be collected from vertical profile soil borings with depth-discrete groundwater samples at the required depths in Table 3 as revised by U.S. EPA and data quality objectives as specified in the QAPP. U.S. EPA will be collecting groundwater samples from existing and to-be-installed monitoring wells. Data obtained from these samples will be used to estimate the



horizontal and vertical extents and to extrapolate the centerline positions of the Eastern Plume. Data will also be used to develop the Eastern Plume remedial design, which will address VOC contamination greater than 100  $\mu$ g/L total VOCs. Work will be performed in accordance with the PDI Work Plan (U.S. EPA, May 2017), with modifications to sample locations as described herein.

# 3.4 Sample Locations

For this project, vertical profile borings will be installed via Roto-Sonic technology and will include visual geologic logging of soils and analytical sampling of groundwater at the depths described in Table 3. Profile boring locations are shown on Figure 3.

		Vertic	Table 3 al Profile Borings		
Profile Boring	Minimum Depth/ Maximum Depth <sup>[1]</sup> (feet bgs)	Target Sample Depth(s) <sup>[2]</sup> (feet bgs)	Target Frequency	Analysis	Notes
Transect 7	Г8		-		
PDI-40	450/520	40, 120 to 440/520	Every 20 feet	VOCs	Not required, pending PDI-41 results
PDI-41	450/520	40, 120 to 440/520	Every 20 feet	VOCs	
PDI-42	450/520	40, 120 to 440/520	Every 20 feet	VOCs	Not required, pending PDI-41 results
Transect 7	Г9				
PDI-43	450/520	40, 220 to 440/520	Every 20 feet	VOCs	May not be required, pending PDI-44 and PDI-45 results
PDI-44	450/520	40, 220 to 440/520	Every 20 feet	VOCs	
PDI-45	450/520	40, 220 to 440/520	Every 20 feet	VOCs	

### Notes:

With approval by U.S. EPA, the boring will be terminated at any depth below 450 feet bgs if two consecutive samples exhibit low VOC concentrations (less than 20 μg/L). A variance from the target depths may be requested based on the laboratory results. Deviations shall not be implemented until approved by U.S. EPA.

Samples will be collected at the water table (expected at approximately 40 feet bgs) and then every 20 feet beginning at the identified depth.

bgs = below ground surface VOC = volatile organic compound

The vertical profile borings will be completed as monitoring wells are installed, as described in Table 4. Monitoring well locations are shown on Figure 3.



Table 4 Monitoring Wells							
Depth   Screen Interval							
Transect T8							
MW-40	-	-	Not required, pending PDI-41 results (If required: 1 well [shallow or intermediate, pending data])				
MW-41	TBD	TBD	up to 2 wells (intermediate or deep, pending data)				
MW-42	-	-	Not required, pending PDI-41 results (If required: 1 well [shallow or intermediate, pending data])				
Transect T9							
MW-43	TBD	TBD	May not be required, pending PDI-44 and PDI-45 results (If required: 1 well [shallow or intermediate, pending data])				
MW-44	TBD TBD up to 2 wells (intermediate or deep, pending data)						
MW-45	TBD	TBD	1 well (shallow or intermediate, pending data)				

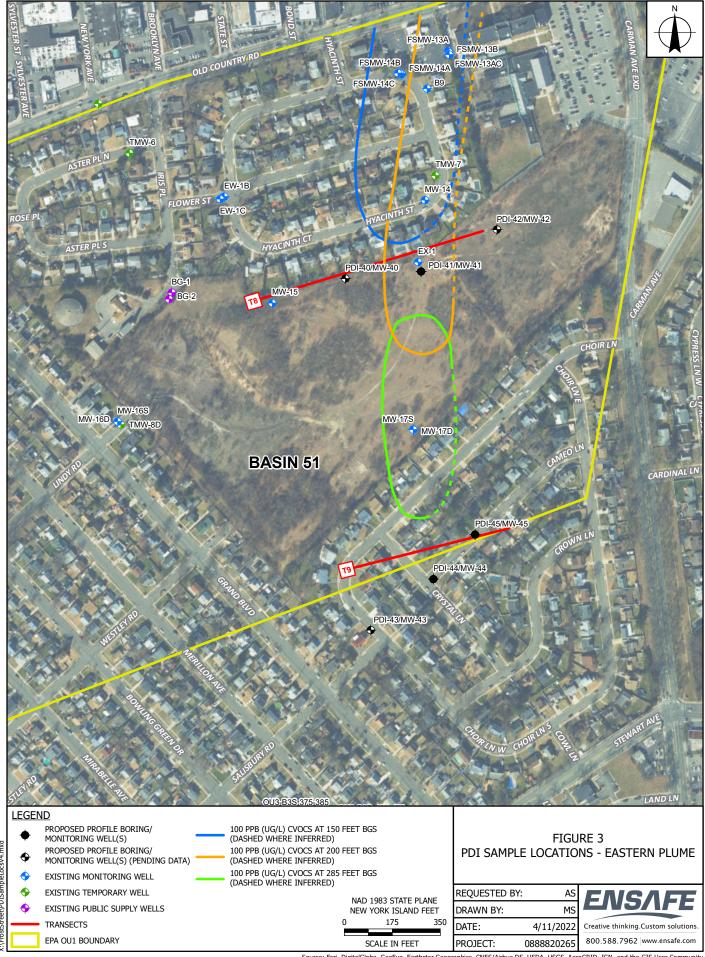
#### Notes:

Pending results of PDI-41, PDI-44, and PDI-45, some of these monitoring wells may not be required. This determination will be made by U.S. EPA.

[2] A shallow well depth means less than 275 feet bgs, an intermediate well depth means between 275 and 350 feet bgs, and a deep well depth shall mean greater than 350 feet bgs.

below ground surface bgs TBD

To be determined based on profile boring data, in consultation with and with approval by U.S. EPA.







### 4.0 GENERAL FIELD PROCEDURES

The field procedures summarized in this section will be used during the installation of soil borings and monitoring wells and the collection of groundwater samples. Field forms are provided in Appendix A and EnSafe Standard Operating Procedures (SOPs) are provided in Appendix B.

### 4.1 Permits and Authorizations

Prior to mobilization, EnSafe and/or its subcontractors will obtain necessary permits and authorizations to perform the work. This includes but is not limited to: coordinating with town and local authorities, obtaining right-of-way permits, and obtaining sewer discharge authorization from Nassau County (Section 4.7.2).

# 4.2 Utility Markout and Clearance

Before drilling activities begin and prior to marking out utilities, all locations will be reviewed with U.S. EPA or their representative in the field. These locations will be evaluated on whether there are conflicts (trees, overhead utilities, spatial constraints, etc.) that would require locations to be adjusted. No adjustments to locations will be made without U.S. EPA's approval.

Utility markout and clearance will be performed in accordance with EnSafe's SOP — Underground Utilities (Appendix B). Prior to drilling or hand clearing, all utilities that pass within a 25-foot radius of the drilling location will be identified.

- The drilling contractor will notify New York 811 at least 2, but not more than 10 days, prior to the commencement of work activities, noting the ticket number.
- The drilling contractor will confirm that each utility has either marked the work site, or given an "all clear", prior to commencing intrusive activities. Approval from the utility/owner is required for work within 15 feet of a utility line.
- A utility markout will be performed by a third-party utility locator to confirm all utilities have been properly identified. Other potential onsite hazards such as sharp objects, known subsurface structures, overhead power lines, and building hazards will also be identified.
- EnSafe will complete a utility checklist (Appendix A) prior to the commencement of intrusive activities.

Before any drilling activities begin, the drilling contractor will hand clear down at least 5 feet bgs at each boring location, even if an underground survey has cleared the location for drilling. If a 5-foot



test hole cannot be achieved based on ground or geologic conditions, the project manager will be notified.

# 4.3 Soil Boring Installation and Depth-Discrete Groundwater Sampling

Soil borings with depth-discrete groundwater sampling will be installed via Roto-Sonic drilling technology, in accordance with EnSafe's SOP — Drilling, Boring, and Direct Push Probing, and the methodology described below.

- Soil borings will be at least 6 inches in diameter.
- Soil samples will be collected utilizing a stainless-steel core barrel advanced via a Roto-Sonic drill rig.
- A larger diameter casing will be advanced over the core barrel.
- The core barrel will be retrieved to the surface.
- Soil samples will be taken directly from the core barrel by extrusion, into large plastic sleeves.
- Depth-discrete groundwater samples will be collected as drilling progresses from desired depths in virgin soil ahead of the drill string by Push-Ahead, or other similar means, to prevent cross contamination. These samples will be collected as follows:
  - A decontaminated and sealed sampler is inserted through the casing to the bottom of the boring.
  - The sampler is sonically driven into the material at a minimum of 5 feet beyond the casing.
  - The sampler is opened to allow water from the formation to enter.
  - The sample is then collected directly from the drill rod using a bailer.
  - Samples will be analyzed for target compound list VOCs via U.S. EPA Method 8260C for low concentrations of VOCs.
  - Submitted for preliminary results with a 24-hour turnaround at the U.S. EPA-approved, local laboratory.
  - Samples will be managed in accordance with the QAPP.



In the event water does not enter the formation or the sampler cannot be deployed at a particular depth due to finer soils, the sampler will be deployed 5 feet deeper and sampling reattempted.

- The core barrel will then be advanced within the large diameter casing to collect the next soil core interval; these steps will repeat until the boring reaches termination depth.
- Soil borings will either be grouted to the surface or completed as monitoring wells, as described in Section 4.4.
- Excess soil will be placed into a United States Department of Transportation (USDOT)-approved 55-gallon drum for disposal and the inner liner properly disposed as indicated in Section 4.7.
- Following boring completion, the core barrel, casing, and other sample collection equipment will be decontaminated as described in Section 4.7.1.

When a soil boring is installed only for the purposes of monitoring well installation immediately adjacent to a borehole previously logged and/or sampled, it does not require soil logging or analytical sample retrieval. In these cases, the borings will be installed via continuous Roto-Sonic drilling, with soils extruded directly into drums for disposal. For this project, the boreholes that will not be logged are anticipated to be the shallower wells at MW-41 and MW-44 (if required).

# 4.4 Soil Logging and Description

Soil logging will be performed in accordance with EnSafe's SOP — Completing Soil Boring Logs, as summarized below. Soils will be described using the American Society for Testing and Materials International D2488-06, Standard Practice for Description and Identification of Soils (Visual-Manual Procedure) for soil classification, which incorporates the Unified Soil Classification System and describes field methodologies for determining the appropriate classification of soil samples based on manual field tests.

- Sample information
  - Method of collection (Roto-Sonic)
  - Sample number
  - Sample depth bgs (top and bottom)
  - Sample recovery (inches)



- Sample time
- Photoionization detector readings in parts per million (12-inch intervals)
- Sample description
  - Grain size (Unified Soil Classification System)
  - Color
  - Structure and other properties
  - Moisture
  - Odors, staining product, or other observed evidence of contamination

The soil description may not necessarily be for the entire sample interval; small-scale units or other changes in soil conditions, within the subsurface soil sample, should be identified and described separately within the sample, as appropriate.

# 4.5 Monitoring Well Installation and Development

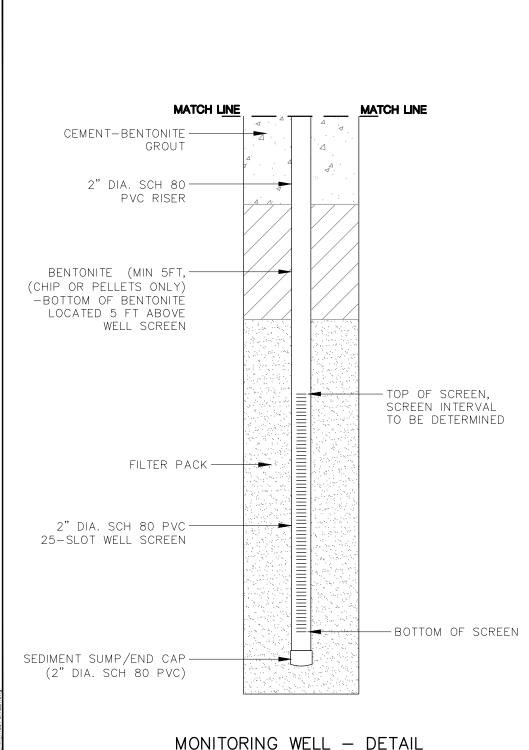
Monitoring wells will be installed at the completion of the soil boring installation and will be developed prior to the collection of groundwater samples, as described in the following sections.

Upon completion of each profile boring, U.S. EPA will be provided with the desired well screen intervals and depths for the monitoring wells on the associated transect prior to the commencement of well construction. To facilitate work progress, U.S. EPA review and comment/approval is requested within 1 week of this submittal.

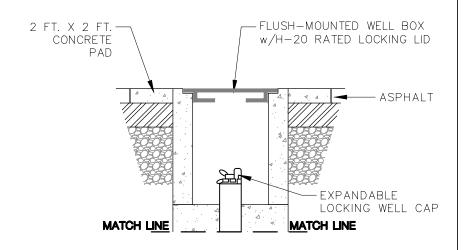
### 4.5.1 Installation

Monitoring wells installed at the desired depths in accordance with the following specifications, as shown on Figure 4:

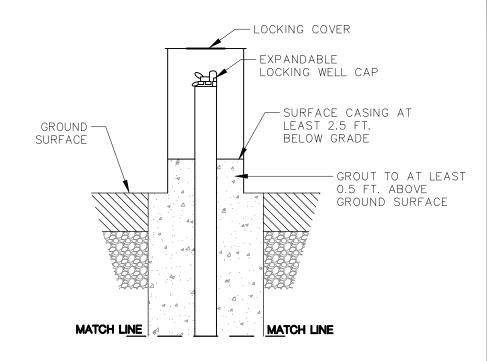
- Monitoring wells will be installed within a minimum 6-inch diameter borehole using Roto-Sonic drilling techniques.
- Monitoring wells will be constructed of 2-inch inside diameter, flush-threaded, schedule 80 polyvinyl chloride (PVC) risers.
- PVC risers will be threaded to a 2-inch inside diameter, 25-slot PVC steel well screen; well screen intervals will be at least 10 feet in length.







# FLUSHMOUNT SURFACE COMPLETION DETAIL NOT TO SCALE



# ABOVE GRADE SURFACE COMPLETION DETAIL

NOT TO SCALE

FIGURE 4	
MONITORING WELL CONSTRUCTION DETAIL	

REQUESTED BY	: AS	ENI
DRAWN BY:	KMB	
DATE:	7/02/2021	Creative thinking
PROJECT:	0888820265	800.588.796





- The well screen section will be threaded to a 2-foot schedule 80 PVC sump and threaded PVC endcap.
- The 2-inch PVC riser will be finished with a water right, locking well cap (e.g., J-plug).
- The cap will be secured to the casing with a non-corrosive padlock; all padlocks will be keyed alike. Keys will be provided to U.S. EPA within 7 days of well installation.
- The annular space around the sump and well screen will be filled with chemically inert filter gravel (#16 well pack, 1/8-inch) that is compatible with the well screen to at least 5 feet above the PVC screen interval. A 5-foot thick minimum, bentonite seal will be placed above the filter pack. The remaining annular space will be tremie grouted with an 80% Portland cement/20% bentonite grout mixture to 3 feet bgs.
- The wellheads will be completed either aboveground or flush mount:
  - Flush mount wells will be completed with a traffic-rated locking or bolted vault, with a minimum 4-inch thick, 2-foot by 2-foot concrete pad.
  - Aboveground completions will use a steel protective casing (at least 5 feet in length) extending about 2.5 feet above ground and set in concrete. The bottom of the steel casing will extend below the frost line. The protective casings inside diameter will be at least 4 inches greater than the nominal diameter of the well riser. The annulus between the protective casing and the well riser will be filled with cement to a minimum of 0.5 feet above ground surface, as part of the overall grouting. A locking hinged cover or slip cap will be fitted at the top of the protective casing to keep precipitation out of the casing.
  - Protective bollards will be installed around the well, outside the concrete pad, for protection from vehicular activity, if necessary.
- The horizontal and vertical coordinates of the adjacent ground surface, vault rim or top of outer protective casing, and a reference point at the top of the newly installed inner well casings will be determined by a New York-licensed land surveyor using equipment and methods that are discussed in the QAPP.

Monitoring wells will be installed in accordance with the schematic provided as Figure 4 and industry standard, including the *Handbook of Suggested Practices for the Design and Installation of Ground-Water Monitoring Wells* (ASTM, March 1991).



# 4.5.2 Development

Monitoring wells will be developed to remove interferences to provide better connection between the well and the formation, improve pumping performance of the well, and collect more representative information from the well (e.g., samples, test results, etc.). Proper well development will:

- Remove drilling residuals (e.g., water, mud) from the borehole and surrounding formation
- Improve or restore hydraulic conductivity of the surrounding formations, which may have been disturbed during the drilling process
- Remove residual fines from the well screen and sand pack (filter pack) materials, thus
  reducing turbidity of groundwater and permitting the collection of more representative
  groundwater samples

The monitoring wells will be developed no sooner than 48 hours after final grouting of the well. Development will be performed by pumping, using a submersible pump; the well will be surged and pumped until well development criteria are met, as follows.

- A minimum of three times the well volume has been removed
- Groundwater parameters for three consecutive standing water volumes are within the following:
  - pH within  $\pm 0.1$  units
  - Specific conductivity within ± 3%
  - Temperature within ±3%
  - Oxidation Reduction Potential (ORP) within ±10 millivolts
  - Turbidity at or below 10 nephelometric turbidity units (NTU) or within  $\pm$  10% if above 10 NTU
  - The sediment thickness remaining within the well is less than 1% of the screen length or less than 30 millimeters (0.1 foot) for screens equal to, or less than, 10 feet long.

Development water will be contained in a tank and/or USDOT-approved 55-gallon drums and will be managed and disposed of in accordance with Section 4.7.

# 4.6 Monitoring Well Groundwater Sampling

At this time, it is understood that U.S. EPA plans to collect groundwater samples from these newly installed monitoring wells and select existing monitoring wells (PDI Directive 1, Round 2). Should

Field Sampling Plan Eastern Plume — Operable Unit 1 New Cassel/Hicksville Groundwater Contamination Superfund Site Nassau County, New York April 2022



U.S. EPA designate the plume groups responsible for this sample collection, samples will be collected as described below.

Groundwater samples will be collected no sooner than 2 weeks following well development in accordance with EnSafe's SOP — FS-03 Groundwater Sampling and SOP — Manual Measurement of Water Levels in Wells, as described below. Well sampling procedures will be recorded in the field logbook and the groundwater sampling form (Appendix A). Sample management is described in the QAPP.

### 4.6.1 Water Level Measurement

Prior to sampling, a depth-to-groundwater measurement will be collected. If possible, the well depth will also be measured.

- Water level measurements will be collected from all wells during a single day.
- Groundwater level elevations will not be collected within 72 hours following large precipitation
  events if the rainfall ponds in Basin 51, as this may temporarily affect the shallow groundwater
  flow conditions.
- Measurements will be made relative to an established reference point (with surveyed elevation data) on the well casing. This reference point is marked by a permanent marker for PVC wells or a notch for stainless steel wells. If no mark is apparent, the person performing the measurements should take both water level and depth measurements from the north side of the top of casing, and note this procedure in the field logbook.
- Measurements will be made with clean, decontaminated water level meters (Section 4.7.1)
  that are appropriately sized for the well consecution and depth-to-water. Serial numbers,
  property numbers, or other unique identification for the water level indicator or sounder will
  also be recorded.
- If known, the cleanest wells should be measured first, followed by the more contaminated locations.
- Measurements will be collected with an electronic water level indicator. The time, date, and measurement to nearest 0.01-foot will be recorded in the field logbook.



- When measuring well depths with the electronic water level indicator, the person performing
  the measurement must measure and add the length of the probe beneath the circuit closing
  electrodes to the depth measured, to obtain the true depth. This is necessary because the
  tape distance markings are referenced to the electrodes, rather than the end of the probe.
- Field probes will be decontaminated before and after use at each well.
- If multiple field teams are used to collect measurements across a large site, then each team should measure the same well, sequentially, at the start of the event to ensure that consistent measurements are being obtained.
- If available, prior measurement event results should be obtained and reviewed by the field investigation team.

# 4.6.2 Low-Flow Groundwater Sampling

Because groundwater samples will be analyzed for VOCs, samples will be collected from monitoring wells via low-flow sample techniques, in accordance with U.S. EPA Guidance *Low Stress (Low Flow) Purging and Sampling Procedure for the Collection of Groundwater Samples from Monitoring Wells* (U.S. EPA, September 2017) and applicable sections of EnSafe SOP FS-03 Groundwater Sampling.

Sampling will progress from the least to most contaminated wells to the extent practical based on available analytical results.

- Each monitoring well will be purged with submersible, peristaltic, or bladder pump and dedicated tubing; sampling will be performed with a submersible or bladder pump. The selected pump should be capable of throttling to a low flow rate suitable for sampling.
- Monitoring wells will be purged at a rate to minimize drawdown within the well to the extent practicable.
- The water quality parameters of temperature, pH, conductivity, salinity, oxygen reduction potential, turbidity, and dissolved oxygen will be measured and recorded, at 5-minute intervals with a multi-parameter water quality probe.
- When the parameters stabilize over three consecutive readings, sampling may commence. Stability is defined as:



- pH within ±0.1 units
- Specific conductivity within ±3%
- ORP within ±10 millivolts
  - Note: ORP is rarely at equilibrium in environmental media and often will not demonstrate enough stability to be used as a purge stabilization parameter.
- Dissolved oxygen within ±10%
- Turbidity at or below 10 NTU or within ± 10% if above 10 NTU
- Samples will be collected at a low-flow rate (between 100 and 250 milliliters per minute), following stabilization.
- If the well goes dry before stabilization is achieved, the well will be sampled when it recovers.
- Sample information will be recorded in the field logbook, dedicated sampling form, and chain
  of custody, as appropriate.
- Samples will be analyzed for target compound list VOCs via U.S. EPA Method 8260C for low concentrations of VOCs and 1,4-dioxane via U.S. EPA Method 522 by a U.S. EPA-approved laboratory.
- A minimum of 30% of the groundwater samples will also be analyzed for ferrous iron (Standard Method [SM]3500-Fe D), dissolved and total metals (U.S. EPA Method 6010), total hardness (SM2340B), and alkalinity (test kit or SM2320B). The Target Analyte List for metals is: aluminum, antimony, arsenic, barium, beryllium, boron, cadmium, calcium, chromium, cobalt, copper, iron, lead, magnesium, manganese, molybdenum, nickel, potassium, selenium, silver, sodium, strontium, thallium, tin, vanadium, and zinc.
- Liquid Wastes will be contained in a frac tank and/or USDOT-approved 55-gallon drums and will be managed and disposed of in accordance with Section 4.7. Personal protective equipment (PPE) and dedicated disposable sampling equipment will be disposed of in garbage bags or USDOT-approved 55-gallon drums in accordance with Section 4.7.

### 4.7 Investigation-Derived Waste

Anticipated wastes include soil, liquid wastes (groundwater and decontamination fluids), PPE, and disposables. All wastes will be segregated by waste streams and placed in USDOT-approved 55-gallon drums, roll-offs, or tanks, as appropriate. Wastes will be temporarily staged in the drilling



work area; once containers are full they will be relocated to a to-be-identified storage area (likely on 89/101 Frost Street). This storage area will be surrounded by chain-link fence and secured with a locked gate.

Investigation derived wastes will be shipped to U.S. EPA-approved offsite facilities in compliance with Section 121(d)(3) of the Comprehensive Environmental Response, Compensation, and Liability Act, 42 United States Code §9621 (d)(3), 40 Code of Federal Regulations §300.440, EPA's Guide to Management of Investigation Derived Waste (U.S. EPA, January 1992).

# 4.7.1 Soil

Soil will be collected and contained within USDOT-approved 55-gallon drums or roll-offs. Wastes will be characterized for offsite disposal; analytical methods and sample frequency will be provided by the to-be-selected disposal facility. A log of all shipments and copies of all manifests and/or bills of lading will be maintained.

### 4.7.2 Liquid Wastes

Prior to mobilization, a Nassau County Department of Public Works (NCDPW) discharge authorization will be procured which will allow for liquid wastes to be discharged to the sewer at pre-selected discharge point(s) for conveyance treatment at the NCDPW publicly owned treatment works. This approval and associated supporting documentation will be provided to U.S. EPA prior to discharging any wastewater into the sewer. Water produced during well development and/or decontamination, will be containerized in 55-gallon drums and/or frac tanks and disposed in accordance with this discharge authorization.

If NCDPW discharge authorization cannot be obtained or is not the selected disposal method, liquid wastes will be containerized in frac tanks and/or USDOT-approved 55-gallon drums and characterized and disposed of offsite at an approved disposal facility.

# 4.7.3 Personal Protective Equipment and Disposables

PPE and disposables will be disposed of as solid waste.

### 4.8 Field Equipment

Field equipment expected to be used is summarized in Table 5.



Table 5 Field Equipment					
Equipment	Material	Dedicated			
Soil sampling sleeves	Plastic	Yes			
Water level indicator	Electronic	No			
Water quality meter	Electronic	No			
Sampling pump with dedicated tubing (not peristaltic)	High density polyethylene tubing	Pump — No Tubing — Yes			
Purging pump with dedicated tubing (if different from sampling pump)	High density polyethylene tubing	Pump — No Tubing — Yes			

# **4.8.1 Equipment Decontamination**

Decontamination of personnel and equipment will be performed to prevent cross-contamination from work areas to public areas (i.e., highways, roads, support trailer, vehicles, etc.).

### Personnel Decontamination

A field decontamination/cleanup area will be available at the drilling work areas and the staging area. Personnel decontamination will be performed in accordance with the Health and Safety Plan.

# Small Equipment Decontamination

Prior to sampling, all non-dedicated equipment (i.e., pumps and water quality meter) will be decontaminated as follows.

- Decontamination of sampling equipment and hand tools may take place at the sampling location as long as all liquids are contained in pails, buckets, etc.
- All sampling equipment will be washed with water and a non-phosphate detergent (e.g., Alconox) to remove gross contamination.
- All sampling equipment will then be rinsed with de-ionized water.
- All equipment will then receive a methanol rinse followed by a de-ionized water rinse.
- At no time will decontaminated equipment be placed directly on the ground.
- Equipment will be wrapped in polyethylene plastic or aluminum foil for storage or transportation from the designated decontamination area to the sampling location, where appropriate.



# Large Equipment Decontamination

Decontamination activities will include the removal of contaminated soil, debris, and other miscellaneous materials from all drilling equipment and tools that have come in contact with contamination. Other drilling equipment, hand tools, and small equipment that come in contact with impacted soil or groundwater will be decontaminated on the decontamination pad in buckets of water and detergent. The augers, rods, and tools will be decontaminated between each drilling location and between samples, as appropriate.

Equipment decontamination will take place on a properly sized temporary decontamination pad. The drill rig itself is unlikely to become grossly contaminated, so the decontamination pad will be sized for the drilling rods and mast. The sides of the pad will be bermed for decontamination water containment.

# **Decontamination Supplies**

A sufficient supply of materials/equipment required to implement decontamination procedures will be maintained, including but not limited to, the following items:

- Large plastic garbage bags
- Wash basins and/or decontamination pad
- Alconox detergent concentrate
- Hand pump sprayers
- Long handled soft bristle brushes
- Large sponges
- Steam generator, if needed
- Liquid detergent and paper towels
- Supplies/equipment to construct the decontamination pads
- All necessary hosing, connections, etc., to collect and transport decontamination fluids to the drums

# 4.8.2 Equipment Calibration and Maintenance

Field meters and equipment will be calibrated according to the manufacturer's guidelines and specifications before and after every day of field use. Equipment calibration and maintenance is described in the QAPP.



# 4.9 Sample Documentation

### 4.9.1 Field Notes

Field logbooks and forms will be used to document all project information in accordance with EnSafe's SOP FD-01 Field Documentation (Appendix B). Field logbooks will be bound with consecutively numbered pages. Data will be recorded promptly, legibly, and in indelible ink on the appropriate logbooks and forms. For each day of field work, the following specific information will also be recorded in the field logbook:

- Team members and their responsibilities
- Time of arrival/entry onsite and time of Site departure
- Other personnel onsite
- Summary of any meetings or discussions with tribal, contractor, or federal agency personnel
- Deviations from sampling plans, Site safety plans, and QAPP procedures
- Changes in personnel and responsibilities with reasons for the changes
- Levels of safety protection
- Calibration readings for any equipment used and equipment model and serial number

At a minimum, the following information will be recorded during the collection of each sample:

- Sample location and description
- Site or sampling area sketch showing sample location and measured distances
- Sampler's name(s)
- Date and time of sample collection
- Designation of sample as composite or grab
- Type of sample (soil, sediment, or water)
- Type of sampling equipment used
- Field instrument readings and calibration



- Field observations and details related to analysis or integrity of samples (e.g., weather conditions, noticeable odors, colors, etc.)
- Preliminary sample descriptions (e.g., for soils: clay loam, very wet; for water: clear water with strong ammonia-like odor)
- Sample preservation
- Lot numbers of the sample containers, sample identification numbers and any explanatory codes, and chain-of-custody form numbers
- Shipping arrangements (overnight air bill number)
- Name(s) of recipient laboratory(ies)

At the completion of a field effort, logbooks and field data forms will be scanned and made electronically available to the project team. The original field forms and logbook will be maintained in the project file.

# 4.9.2 Photographs

Photographs may be taken at the sampling locations and at other areas of interest onsite or at the sampling area. For each photograph taken, the following information will be written in the logbook or recorded in a separate field photography log:

- Time, date, location, and weather conditions
- Description of the subject photographed
- Name of person taking the photograph



### 5.0 REFERENCES

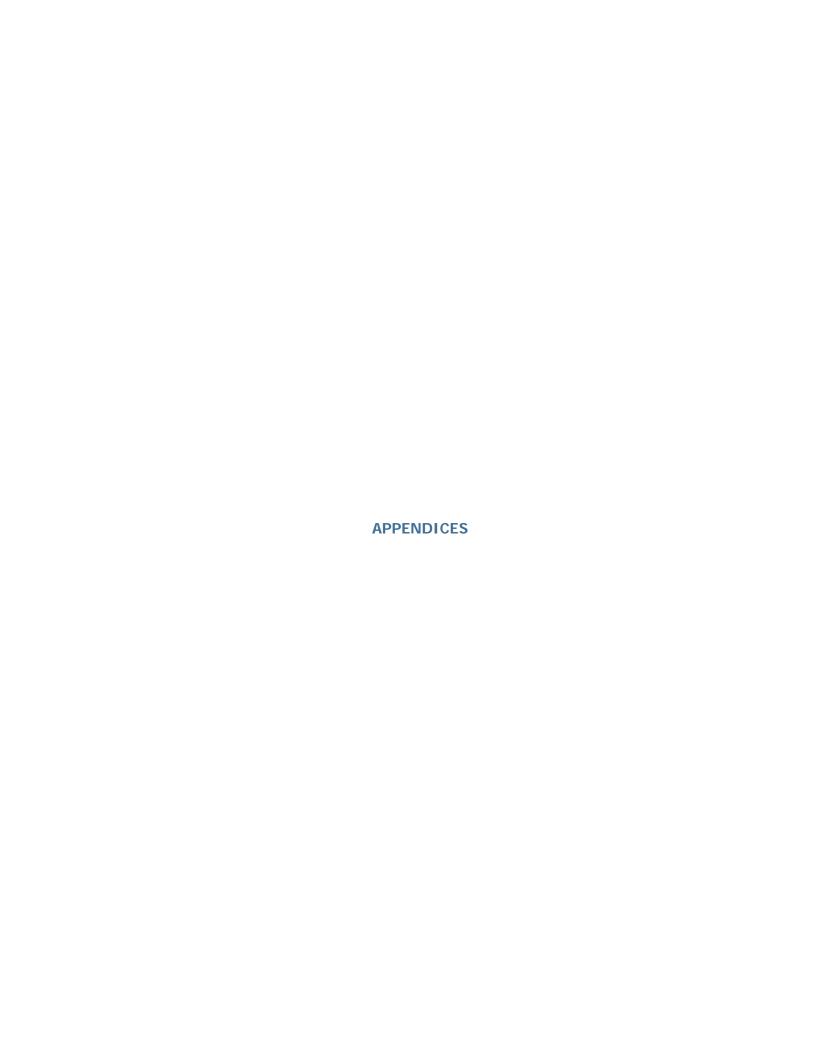
American Society for Testing and Materials. *Handbook of Suggested Practices for the Design and Installation of Ground-Water Monitoring Wells.* March 1991.

EnSafe Inc. Emergency Response Plan – Eastern Plume, New Cassel/Hicksville Groundwater Contamination Superfund Site. Nassau County, New York. April 2022.

- Health and Safety Plan Eastern Plume, New Cassel/Hicksville Groundwater Contamination
   Superfund Site. Nassau County, New York. April 2022.
- Quality Assurance Project Plan Eastern Plume, New Cassel/Hicksville Groundwater
   Contamination Superfund Site. Nassau County, New York. April 2022.
- Site Management Plan Eastern Plume, New Cassel/Hicksville Groundwater Contamination
   Superfund Site. Nassau County, New York. April 2022.

United States Environmental Protection Agency. *EPA's Guide to Management of Investigation Derived Waste. OSWER 9345.3-03FS.* January 1992.

- New Cassel/Hicksville Groundwater Contamination Site, OU1 RD Pre-Design Work Plan. May 2017.
- Low Stress (Low Flow) Purging and Sampling Procedure for the Collection of Groundwater
   Samples from Monitoring Wells. EQASOP-GW4. September 2017.
- Record of Decision, Operable Unit 1, New Cassel/Hicksville Ground Water Contamination Superfund Site, Towns of North Hempstead, Hempstead and Oyster Bay, Nassau County New York. September 2013.



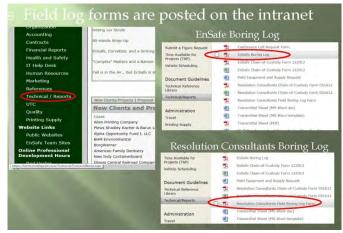
Appendix A Field Forms

# EnSafe Field Soil Boring Log – General Use Guidelines December 5, 2014

The EnSafe field soil boring log form should be used for logging soil borings for all site investigations, except when a lead agency program (e.g. Tennessee UST program or Florida programs) requires otherwise, or when a specific form is required per a Work Plan, Sampling and Analysis Plan (SAP), Quality Assurance Project Plan (QAPP), or Field Sampling Plan (FSP).

Field soil boring logs for EnSafe and Resolution Consultants are accessible from the Intranet under Technical/Reports-Forms (see inset to the right).

Industry and company standards require use of the ASTM International D2488-06 Visual Manual Method for soil classification; below are guidelines for completing the form. The ASTM standard incorporates the Unified Soil Classification System (USCS) classification system and describes field methodologies for determining the appropriate



classification of soil samples based on manual field tests. The ASTM standard as well as other reference materials are attached. More information about logging and describing rock and other geologic material will be included in an amendment to this guidance at a future date.

A mock-up of a completed field soil boring log and a completed LogPlot report log, based on the template of the field form, are attached for guidance.

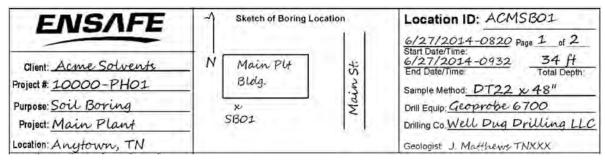
### Guidelines for Completing the Field Soil Boring Log

The soil boring log form comprises a header, body, and end notes. Specifics of each part are described below.

#### Header

The header includes an area for project information, a sketch of the boring location, location ID, and equipment information (see Inset 1 below).

*Project Information* — The left header box is for general project information. Most of this information is straightforward. The illustration is for a soil boring, but this form would also be used for a temporary well, monitoring well, injection well, injection point, recovery well, and so forth.



Inset 1: Header

Sketch of Boring Location — Center header box is available for a simple sketch of the boring location relative to site features and other soil borings. This is a simple task to complete and can be very valuable if there are any questions down the road about a boring location.

Location and Equipment Information — The right header box is for entering the location ID, drilling start and end date and time, number of pages, total boring depth, drilling information, and geologist or field scientist. Most of this information is straightforward, but options for the drilling information will vary depending on drilling method and sampling method.

<u>Sampling Methods:</u> Define the type of sampler used for retrieving the soil samples. Samplers include devices associated with different drilling methods (identified under "Drilling Equip" on the header. Below is a table with basic information for sampler devices <u>typically</u> available.

Drilling Equip/Method	Common Make	Sample Method (Entry On Log)	Sampler Description
Direct Push (DP)	Geoprobe (Gp)	DT22 x (Length as -in or -ft)	Dual tube 2.25-inch diameter
		DT325 x (Length as -in or -ft)	Dual tube 3.25-inch diameter
		DT45 x (Length as -in or -ft)	Dual tube 4.5-inch diameter
		M5 x (Length as -in or -ft)	Macro Core 2.25-inch diameter
		M7 x (Length as -in or -ft)	Macro Core 3.0-inch diameter
Hollow-Stem Auger	Central Mining	SS x (Length as -in or -ft, dia. as -in)	Split-spoon (or split-barrel) is a carbon steel
(HSA)	Equipment (CME)	CS x (Length as -in or -ft, dia. as -in)	sampler, typically 18 or 24 inches long and 2
Solid-Stem Auger (SSA)	Mobile	(CS with HSA method only)	or 3 inches in diameter
	Various		Continuous Sampler (CS) is typical carbon
			steel 60 inches long and 3-inch diameter.
Fluid Rotary (FR)	CME	SS x (Length as -in or -ft, dia. as -in)	SS (see above for details)
includes mud and air	Various		
Sonic	Geoprobe	Sonic x (Length -in or -ft, dia. as -in)	Steel typically 5 or 10 feet long with varying
	TerraSonic		diameter (3, 4, 6 inches)
	Various		
Hand Auger (HA)	Various	HA x (Length as -in or -ft, dia. as -in)	Auger Bucket Stainless Steel
Slide Hammer	Various	SH x (Length as -in or -ft, dia. as -in)	Sample Tube Stainless Steel or Acetate

### Log Form Body

The body of the log form includes data columns to the left and lithologic descriptions to the right (Inset 2). Information for each column is on the left is described below.

Sample luterval	Recovered Secondary Driven	Miscellaneous (Time/Blow Ct)	OVA Reading (ppm)	nscs	ОЕРТН (FT)	Lithologic Description  Visual-Manual Description (ASTM D 2488-06)  (e.g.: Grain size, color, structure and other properties, moisture, odor, staining)
1/4	42/48	0822	0.0	Asph CL	0- 1-	(0 - 4 ft) Asphalt with gvl base (0 - 0.5 ft); Silty Clay, brn, firm, low plst, slgt moist.
/	4		0.0		2	
/	-		0.0		3=	
2 /8	44 48	0825	0.2		4	(4 - 8 ft) Silty Clay, brn grd gry, firm, low plst, slgt moist:

**Inset 2**: Example of left column data columns and right lithologic descriptions. Note the preferred order and recommended basic information to enter in the heading.

*Left Section* — The section of the form body is the area where information is recorded regarding sample run, recovery, miscellaneous information, organic vapor analyzer (OVA) readings (typically parts per million [ppm]), USCS classification group code, and depth graph.

<u>Sample:</u> Sample run is typically used to denote each sample run as a serial count (upper number) and the run end or bottom depth (lower number) as feet below ground surface (bgs). This information is very useful for keeping track of the boring depth during drilling and verifying with the driller regarding the bottom depth of each run (this will vary based on drilling method, sampling equipment, drillers, and specific site conditions).

<u>Recovery:</u> Enter inches of sample recovered (upper number) and inches driven (lower number) for each sample run. Calculate percent recovered by dividing the lower number into the upper number and multiplying by 100. Percent recovered will be shown on the report log prepared using LogPlot.

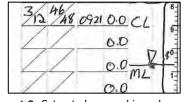
<u>Miscellaneous:</u> This column may be used to record a variety of information. A suggested use for this column is to enter the time the sampler is retrieved from the borehole; this would be the best sample time used for laboratory samples as it represents the initial time the sample was exposed to the atmosphere.

OVA Reading (ppm): Enter the field screening and/or sample head space measurement from the OVA meter. You may enter the OVA type (e.g., photoionization detector [PID], flame-ionization detector [FID], etc.) in the notes at the bottom or in the space in the header above "(ppm)."

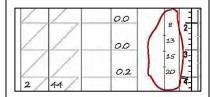
<u>USCS</u>: This column is for entering the group classification per the USCS. The ASTM D 2488-06 standard provides detailed information regarding field visual-manual methods for determining the proper USCS group. More information is discussed below under "Lithologic Description."

<u>Depth (FT):</u> This column is a scaled graph for recording information at specific depth intervals. Space is available to the left to enter information such as blow counts (split-spoon sampling), and water levels (Inset 3).

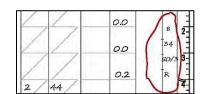
The space along the depth scale may also be used to enter blow counts as shown in Insets 4 and 5, or a graphic sketch of lithologic types. Other information to note in the "Depth" scale column includes analytical sampling intervals (Inset 6 below). More extensive notes would be entered in with the lithologic descriptions. Please see the attached mock-up log form for more examples.



Inset 3: Saturated on graphic scale



Inset 4: Blow counts. Blow counts are entered as number of hammer falls per 6-inch increment the split-spoon is driven. The first 6 in. of drive is considered to be a seating drive. The sum of the blows required for the second and third 6-inch increments of penetration is termed the "standard penetration resistance" or the "N value."

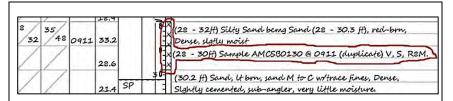


**Inset 5:** Blow counts with rejected run. Typically, a split-spoon is considered rejected when minimal penetration occurs over 6 inches with a maximum of 50 blows.

How to use blow counts while logging:

	ands reliable)	Clays (Rather reliable)		
Number of blows per foot (30 m), N	Relative density	Number of blows per foot (30 cm), N		
		Below 2	Very soft	
0-4	Very loose	2-4	Soft	
4-10	Loose	4-8	Medium	
10-30	Medium	8-15	Stiff	
30-50	Dense	15-30	Very stiff	
Over 50	Very dense	Over 30	Hard	

Lithologic Description: This is the main section of the field soil boring log form and should be used to describe the lithologic sample per the ASTM D 2488-06 standard to meet industry standards. It details the USCS group classifications and provides the visual-manual field



**Inset 6:** Sample intervals can be shown graphically along the depth graph (seen here as "x" over a 2-foot interval). Notes for sample IDs, time and analyses may be entered in the log narrative section or the endnotes (discussed below).

tests and methodology for determining the USCS groups. The last attachment to this guidance is a quick reference guide for the USCS classification system with very brief descriptions of the visual-manual field test; this is a good "Cheat Sheet" to carry in the field.

There are different approaches to entering the narrative description of the lithology, but as shown in Inserts 1 and 6, there is a recommended preference for the primary information and order for entering the description. Depth should be recorded for all entries to minimize errors. Some basic examples of lithologic descriptions are provided in the examples on the attached mock-up log form. More information is preferred and recommended, but the examples show the basic information acceptable (although "same as above" or "SSA" is a personal preference and is acceptable as long is the previous description remains accurate with depth).

Descriptions should be entered in the following order and include the basic information as defined in the ASTM D 2488-06 standard:

Grain size, color, structure and other properties, moisture, odor, staining, product or other observed evidence of contaminants.

Other notes may also be entered in the lithologic description section of the log form, including soil samples collected for laboratory analysis (including Shelby tubes for geotechnical data) and organic and inorganic samples for contaminant assessments. However, space is provided in the end notes to record this information as well (see below).

#### **End Notes**

The end notes include space to enter general notes, basic well construction information, and laboratory sampling information for up to five samples (Inset 7). The end notes are intended as a supplement to other documents and do not replace the necessity of entering information into the field logbook, the sampling chain-of-custody form, or, as required a well construction completion form (attached). The best recommended use for the end notes is to record the listed information for easy reference and to facilitate completion of the report soil boring log in LogPlot. This also facilitates recording this information for smaller projects such as a Phase II ESA.

Notes:	Well Constuction		Тор	Base	Sample ID	Time	Interval	Analyses
Abd by pres growt w/tremie	Material:	Casing:			1) ACMSSB0112	0829	10.5-12ft	V, S, R8Met
Cuttings placed in Drum	Diameter:	Screen:			2) ACMSSB0130	0911	28-30ft	V, S, R8Met
#001.	Wellhead:	Grount:			3) ACMCSB0130	0911	28-30ft	V, S, R8Met
	Ballards:	Bent/Seal:			4)			
	Pad:	Sand Pack:			5)			

Inset 7: End Notes for recording basic well construction information and sampling information

#### Reporting

The field log form is designed to work directly with a template (form) and data (.dat) input file within LogPlot. Templates are available for soil borings as well as monitoring wells. Template and corresponding .dat files are at:

#### **EnSafe Logo Logs**

\\esbackup\Data\LogPlot Templates\EnSafe Templates\

Soil Boring Log Template — EnSafe-Report Soil Boring Log Form\_2014.ldfx Monitoring Well Log Template — EnSafe-Report Monitoring Well Log Form\_2014.ldfx Data (.dat) file for both log forms — Soil Boring&Monitoring Well Final DAT File.dat

#### **Resolution Consultant Logo Logs**

\\esbackup\Data\LogPlot Templates\Resolution Consultants Template\

Soil Boring Log Template — Resolution Consultants-Report Soil Boring Log Form\_2014.ldfx Monitoring Well Log Template — Resolution Consultants-Report Monitoring Well Log Form\_2014.ldfx Data (.dat) file for both log forms — Soil Boring&Monitoring Well Final DAT File.dat

There will be presentations prepared and distributed regarding training and tips for using LogPlot to produce soil boring and monitoring well logs for reports. However, below are some of the more critical actions that shall be done when working on report logs.

*Project Files* — Always save a copy of the LogPlot template (.ldfx) file to your project directory and **DO NOT** edit or overwrite the standard .ldfx or .dat files in the template directories listed above.

*Identify the template file* — In LogPlot, the "E-Text" tab is used to enter the pathway and file name for the template file used. This is critically important if the log needs to be edited and reproduced by another person or at a later date. More information will be provided with LogPlot training.

*USCS Symbols* — LogPlot comes with the standard USCS symbols and colors as a default. Symbols are saved in a "Keyword" file on the "C:" drive of the user's computer where LogPlot is installed. You may add symbols to a keyword file, but **DO NOT** delete or modify USCS keywords as this is a local modification and will not be consistent from one computer user to the next.

#### Closing

The field soil boring log form is recommended for use unless superseded by a specific form as stated in the introduction. Some states, such as Florida, or specific state programs such as the Tennessee UST program, require specific forms for recording and reporting soil boring and monitoring well logs. Also, specific forms may be warranted in some cases; however, the field soil boring log form discussed in these guidelines is the recommended form and should be used for continuity throughout the company.

This guidance will be updated and appended and distributed through the field services group periodically. Please direct any questions or comments to Joe Matthews (x4236) or Shane Goodnight (x2827).

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				=	-						Start Da	ite/Time:		Page	of
Clie	ent:										End Da	te/Time:		T	otal Depth:
Projec	:t #:										Sample	Method:			
Purpo	Purpose:														
	Project:														
Locati															
	Recovery	s £	50.	1					l ith	ologic Desc	Geologi	ST:			
		5 5	OVA Reading (ppm)		ОЕРТН (FT)			Visua		al Description	-	2488-0	16)		
Number Interval	Inches Recovered Inches Driven	iscell.	VA R	nscs	EPT	(4	e a · Grair			cture and oth				or stair	nina)
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				1	Wellhead:		Grount:			3)					
				E	Ballards:		Bent/Seal:			4)					

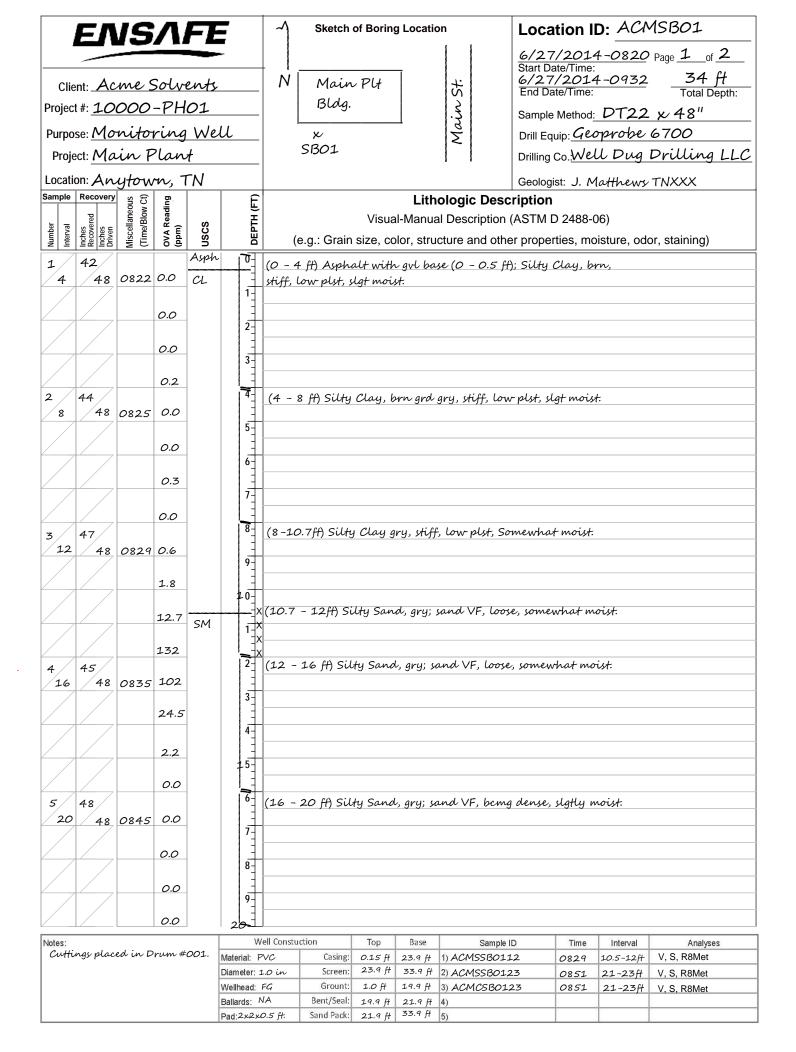
Pad:

Sand Pack:

5)

#### **Well Construction Form**

Facility/Project Name:	Well ID.:
Facility License Number:	Type of Well:  Ground Water Monitoring  Piezometer ☐ Injection ☐  Other
Date Well Installed:	Location of well relative to waste source:
Well Installed By:	Upgradient Downgradient Side-gradient Unknown
	Well Driller License Number:
Geologist:	1. Cap and lock?  Yes  No
A. Protective pipe: ft. above grade	2. Protective cover pipe:
B. Well casing, top elevation: ft. MSL	a. Inside diameter: in.
C. Land Surface Elevation: ft. MSL	b. Length: ft.
D. Surface seal, bottom: ft.below grade	c. Material: Steel ☐ Other
12. USCS classification of soil near screen:	3. Surface seal: Bentonite  Concrete
GP□ GM □ GC □ GW □ SP □ SM □	Other:
SC SW ML MH CL CH	4. Material blw. well casing and protective pipe:
Bedrock ☐  13. Sieve analysis attached? Yes ☐ No ☐	Bentonite
14. Drilling method used: Rotary  HSA	Other:
Other:	5. Annular space seal: (Manufacturer name)
15. Drilling fluid used:	a. Granular bentonite
Water ☐ Air ☐ Drilling Mud ☐ None ☐	b. Bentonite/Cement slurry
16. Drilling additives used? Yes ☐ No ☐ Specify:	% bentonite Bentonite/cement grout Lbs/gal mud weight bentonite slurry
17: Source of water:	c. How installed: Tremie   Tremie pumped
E. Bentonite seal: top ft. (depth)	Gravity□
E Fire and the fit (doub)	6. Bentonite seal: (Manufacturer, product name)
F. Fine sand: top ft. (depth)	→ Bentonite granules □
G. Filter pack: top ft. (depth)	□ ¼ in. □ 3/8 in. □ ½ in. Bentonite pellets □
H. Screen joint top: ft. (depth)	Other: 7. Fine sand material: (Manufacturer, product name, mesh size)
I. Well bottom: ft. (depth)	Volume added: ft <sup>3</sup>
J. Filter pack: bottom ft. (depth)	
K. Borehole: bottom . ft.( depth)	8. Filter pack material: (Manufacturer, product name, mesh size)
Borehole diameter: in.	Volume added: ft <sup>3</sup>
	9. Well casing: Flush-threaded Sch 40 PVC□
	Flush-threaded Sch 80 PVC□
CERTIFICATION	Other:
CERTIFICATION:  I hereby certify that the information on this form is true	10. Screen material:
and correct to the best of my knowledge:	a. Screen type: factory cut ☐ continuous slot ☐
	Other:
(Signature)	b. Manufacturer:
	c. Slot size: 0. in.
(Company Name)	d. Slotted length: ft.
	11. Backfill material: or None



	EΛ	<b>IS</b>	Λ	FE	=	Sketc	h of Borin	g Location	on	Loca	tion II	D: ACA	1SB01
· '		_		~	-					6/27	/2014		Page <u>2</u> of <u>2</u>
Clie	ent: Ac	me s	Solv	ents		Se	e pg	1		↓ Start Da	ta/Tima·		34 ft Total Depth:
	t#:_1.C						1 5					See	-
	se: <u>So</u>									1		11	
	ect: Ma		•	•								11	
Locati	on: An	utow	m.	TN						Geologis	st: J.	Matth	ews TNXXX
	Recovery	ous /Ct)	Bu <u>i</u>		Ē			Lith	ologic Desc				
al al	Inches Recovered Inches Driven	Miscellaneous (Time/Blow Ct)	OVA Readin (ppm)	ဟ္လ	DEPTH (		Visua	al-Manua	al Description	(ASTM D	2488-0	06)	
Number	Reco Inche Drive	Misc (Tim	O V P	nscs					cture and other				or, staining)
6	47/		0.2	SM	20-	(20 - 24 ft) S dense, slgtly n		d, gry to	red-brn; sav	nd VF, so	mewha	<i>t</i>	
/24	48	0851		-	1 1 X	aense, sigrig n	wist						
			0.0		X								
					2=								
$\leftarrow$			0.0	-	3-X								
			0.3										
7/	46/				4	(24 - 28ft) S		d, red-b	rn; sand VF	to F, Der	ıse,		
28	48	0906	0.0	-	25-	somewhat me	rist.						
			0.0										
					6-								
			23.5	_									
			18.9		' =								
8	35/				8-	(28 - 32ft) S	'Ity Sano	l berng s	Sand (28 - 3	0.3 ft), r	ed-brn	5	
/32	48	0911	33.2	-		Dense, moist							
			28.6		[ ]								
					30-	(30.2 ft) Sand	d, lt brn,	, sand N	1 to C w/trace	e fines, I	Dense,		
<u>/</u>			21.4	SP		Slghtly cemer	rted, sub	-angler	, very moist.				
			0.1		[']								
9 /	19/		0.4		2-	(32 - 34 ft) S	iand, lt l	brn; san	d M to C, De	nse, slgtl	y		
34	22	0918	0.0	_	3-	cemented, su	s-angler	; wet - 1	Rejected at 3:	3.9 ft.			
					4				~~~~~	~~~~			
<u>/</u>				-	<u> </u>	Boring	termina	ited at 3	3.9 ft bgs	DPT Rej	ected		
					35-								
/				-	6-								
<u>/</u>				-	<u> </u>								
					7-								
				-	8-								
<u>/</u>					]								
					9-								
Notes:						ell Constuction	Тор	Base	Sample	ID.	Time	Interval	Analyses
	C	Dese	1		Material:	Casin	g:		1)	A-7-0			, mayoo
	<i>&gt;ee</i>	Page	1		Diameter:	Scree Grour			2)				
					Wellhead:	Rent/Se:		1	3)				

Sand Pack:

5)

Pad:

#### **Well Construction Form**

Facility/Project Name: Acme - Main Plant	Well ID.: ACMSB01
Facility License Number: None	Type of Well:  Ground Water Monitoring  Piezometer ☐ Injection ☐  Other
Date Well Installed: 6/27/2014 Lo	ocation of well relative to waste source:
Well Installed By: Well Dug Drilling $U_{\parallel}$	pgradient ☐ Downgradient ☑ Side-gradient ☐ Unknown ☐
Geologist: J. Matthews	Well Driller License Number: TN XXXXXX
Nov. a. F.C.	1. Cap and lock? ☐ Yes ☑ No
A. Protective pipe: None FG ft. above grade	2. Protective cover pipe: 8-inch, load bearing flush-grade man
B. Well casing, top elevation: 419.8 ft. MSL	a. Inside diameter: in.
C. Land Surface Elevation: 420.0 ft. MSL	b. Length: <u>1.0</u> ft.
D. Surface seal, bottom: 21.9 ft.below grade	c. Material: Steel⊠ Other
12. USCS classification of soil near screen:	3. Surface seal: Bentonite ☐ Concrete ☑
GP□ GM □ GC □ GW □ SP □ SM ☒	Other:
SC SW ML MH CL X CH	4. Material blw. well casing and protective pipe:
Bedrock	Bentonite 🗌 Annular space seal 🗎
13. Sieve analysis attached? Yes No	Other: Concrete
14. Drilling method used: Rotary HSA	5. Annular space seal: (Manufacturer name)
Other: Direct Push	a. Granular bentonite 🗵
15. Drilling fluid used:	b. Bentonite/Cement slurry
Water	_5% bentonite Bentonite/cement grout  Lbs/gal mud weight bentonite slurry  □
Specify:	
17: Source of water: Potable	c. How installed: Tremie Tremie pumped
E. Bentonite seal: top 19.9 ft. (depth)	Gravity_
F. Fine sand: top ft. (depth)	6. Bentonite seal: (Manufacturer, product name)
G. Filter pack: top 21.9 ft. (depth)	Bentonite granules □    3/8 in.   1/2 in. Bentonite pellets
H. Screen joint top: 23.9 ft. (depth)	Other:
I. Well bottom: 33.9 ft. (depth)	7. Fine sand material: (Manufacturer, product name, mesh size)  Volume added: Nove ft <sup>3</sup>
J. Filter pack: bottom ft. (depth)	
K. Borehole: bottom:33.9ft.( depth)	8. Filter pack material: (Manufacturer, product name, mesh
Borehole diameter: in.	size) 20/40 sand  Volume added: Appx 2.4 ft <sup>3</sup>
	9. Well casing: Flush-threaded Sch 40 PVC
\	Flush-threaded Sch 80 PVC
	Other: 1.0 inch diameter
CERTIFICATION:	10. Screen material: PVC 1.0 inch diameter
I hereby certify that the information on this form is true and correct to the best of my knowledge:	a. Screen type: factory cut ⊠ continuous slot □
, ,	Other:
(Sion atoms)	b. Manufacturer:
(Signature)	c. Slot size: 0. 01_in.
(Common News)	d. Slotted length: 10 ft.
(Company Name)	11. Backfill material: 20/40 sand or None
	• 11. Dackim material. 207-70 yards 01 None

# ENSAFE

and **Monitoring Well Log** 5724 Summer Trees Drive Memphis, TN 38134

Client: Acme Solvents Project #: 10000-PH01 Purpose: Phase II ESA Project: Main Plant

Sample Method: DT22 x 48" Drill Equipment: Geoprobe 6700 Drilling Company: Well Dug Drilling LLC

**Soil Boring Log** 

Location ID: ACMSB01

Start Date/Time: 6/27/2014 - 0820 End Date/Time: 6/27/2014 - 0932

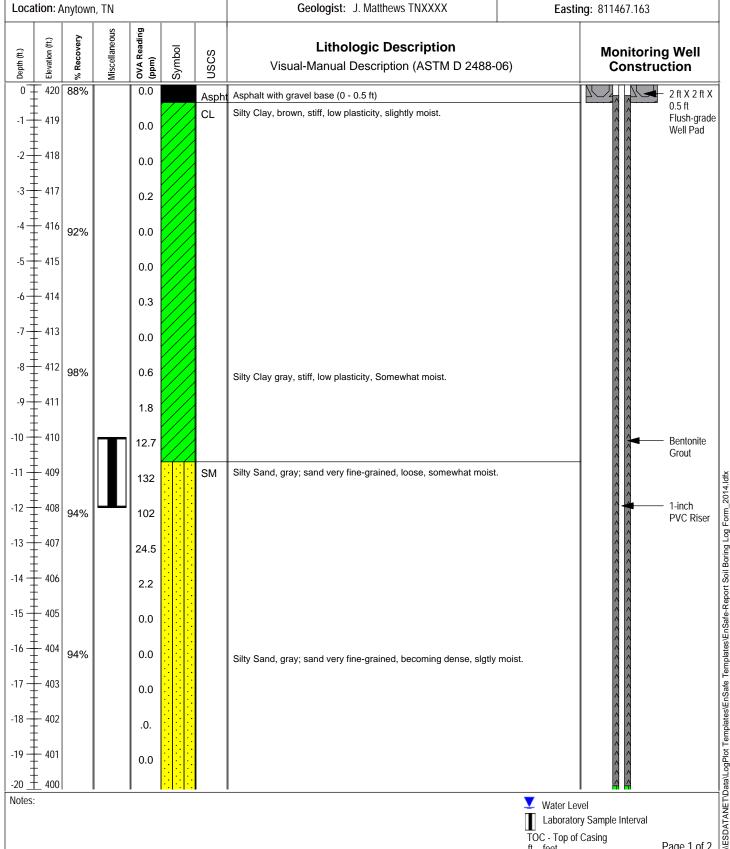
Total Depth: 34 ft. Ground Elevation: 420.0 ft. TOC Elevation: 419.8 ft. Northing: 325797.95 Easting: 811467.163

Laboratory Sample Interval

Page 1 of 2

TOC - Top of Casing

ft. - feet



## ENSAFE

5724 Summer Trees Drive Memphis, TN 38134

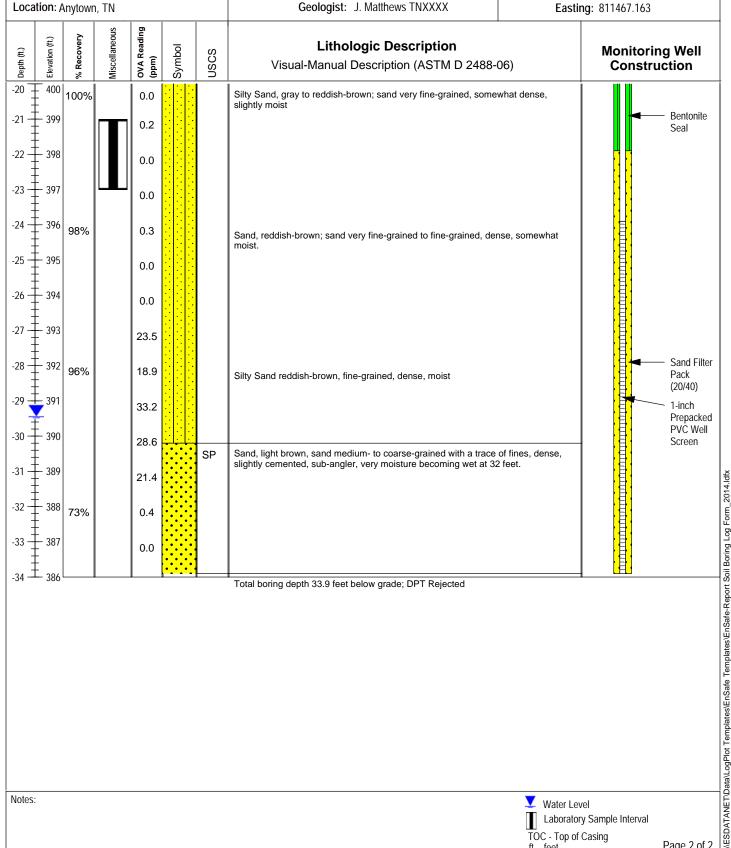
#### Soil Boring Log and **Monitoring Well Log**

Client: Acme Solvents Project #: 10000-PH01 Purpose: Phase II ESA Project: Main Plant

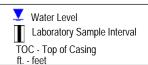
Sample Method: DT22 x 48" Drill Equipment: Geoprobe 6700 Drilling Company: Well Dug Drilling LLC Geologist: J. Matthews TNXXXX Location ID: ACMSB01

Start Date/Time: 6/27/2014 - 0820 End Date/Time: 6/27/2014 - 0932

Total Depth: 34 ft. Ground Elevation: 420.0 ft. TOC Elevation: 419.8 ft. Northing: 325797.95 Easting: 811467.163



Notes:





Client: Acme Solvents

Project #: 10000-PH01

Location: Anytown, TN

Purpose: Monitoring Well

Project: Main Plant/AOC A

5724 Summer Trees Drive Memphis, TN 38134

### Soil Boring Log **Monitoring Well Log**

Sample Method: DT22 x 48" Drill Equipment: Geoprobe 6700

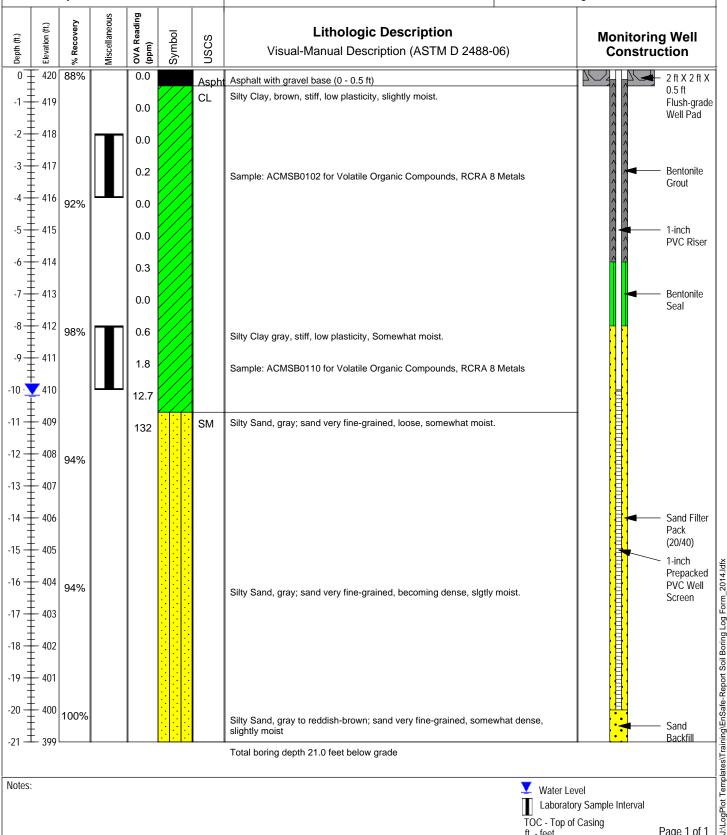
Drilling Company: Well Dug Drilling LLC

Geologist: J. Matthews TNXXXX

Location ID: ACMSB01

Start Date/Time: 6/27/2014 - 0820 End Date/Time: 6/27/2014 - 0932

Total Depth: 21 ft. Ground Elevation: 420.0 ft. TOC Elevation: 419.8 ft. Northing: 325797.95 Easting: 811467.163



Total boring depth 21.0 feet below grade

Notes:



Page 1 of 1



Designation: D 2488 - 06

# Standard Practice for Description and Identification of Soils (Visual-Manual Procedure)<sup>1</sup>

This standard is issued under the fixed designation D 2488; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon  $(\epsilon)$  indicates an editorial change since the last revision or reapproval.

This standard has been approved for use by agencies of the Department of Defense.

#### 1. Scope\*

1.1 This practice covers procedures for the description of soils for engineering purposes.

1.2 This practice also describes a procedure for identifying soils, at the option of the user, based on the classification system described in Test Method D 2487. The identification is based on visual examination and manual tests. It must be clearly stated in reporting an identification that it is based on visual-manual procedures.

1.2.1 When precise classification of soils for engineering purposes is required, the procedures prescribed in Test Method D 2487 shall be used.

1.2.2 In this practice, the identification portion assigning a group symbol and name is limited to soil particles smaller than 3 in. (75 mm).

1.2.3 The identification portion of this practice is limited to naturally occurring soils (disturbed and undisturbed).

Note 1—This practice may be used as a descriptive system applied to such materials as shale, claystone, shells, crushed rock, etc. (see Appendix X2).

- 1.3 The descriptive information in this practice may be used with other soil classification systems or for materials other than naturally occurring soils.
- 1.4 The values stated in inch-pound units are to be regarded as the standard.
- 1.5 This standard does not purport to address all of the safety problems, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use. For specific precautionary statements see Section 8.
- 1.6 This practice offers a set of instructions for performing one or more specific operations. This document cannot replace education or experience and should be used in conjunction with professional judgment. Not all aspects of this practice may

be applicable in all circumstances. This ASTM standard is not intended to represent or replace the standard of care by which the adequacy of a given professional service must be judged, nor should this document be applied without consideration of a project's many unique aspects. The word "Standard" in the title of this document means only that the document has been approved through the ASTM consensus process.

#### 2. Referenced Documents

2.1 ASTM Standards: 2

D 653 Terminology Relating to Soil, Rock, and Contained Fluids

D 1452 Practice for Soil Investigation and Sampling by Auger Borings

D 1586 Test Method for Penetration Test and Split-Barrel Sampling of Soils

D 1587 Practice for Thin-Walled Tube Sampling of Soils for Geotechnical Purposes

D 2113 Practice for Rock Core Drilling and Sampling of Rock for Site Investigation

D 2487 Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System)

D 3740 Practice for Minimum Requirements for Agencies Engaged in the Testing and/or Inspection of Soil and Rock as Used in Engineering Design and Construction

D 4083 Practice for Description of Frozen Soils (Visual-Manual Procedure)

#### 3. Terminology

3.1 *Definitions*—Except as listed below, all definitions are in accordance with Terminology D 653.

Note 2—For particles retained on a 3-in. (75-mm) US standard sieve, the following definitions are suggested:

Cobbles—particles of rock that will pass a 12-in. (300-mm) square opening and be retained on a 3-in. (75-mm) sieve, and

Boulders—particles of rock that will not pass a 12-in. (300-mm) square opening.

<sup>&</sup>lt;sup>1</sup> This practice is under the jurisdiction of ASTM Committee D18 on Soil and Rock and is the direct responsibility of Subcommittee D18.07 on Identification and Classification of Soils.

Current edition approved Nov. 1, 2006. Published November 2006. Originally approved in 1966. Last previous edition approved in 2000 as D 2488 – 00.

<sup>&</sup>lt;sup>2</sup> For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

- 3.1.1 clay—soil passing a No. 200 (75-µm) sieve that can be made to exhibit plasticity (putty-like properties) within a range of water contents, and that exhibits considerable strength when air-dry. For classification, a clay is a fine-grained soil, or the fine-grained portion of a soil, with a plasticity index equal to or greater than 4, and the plot of plasticity index versus liquid limit falls on or above the "A" line (see Fig. 3 of Test Method D 2487).
- 3.1.2 gravel—particles of rock that will pass a 3-in. (75-mm) sieve and be retained on a No. 4 (4.75-mm) sieve with the following subdivisions:

coarse—passes a 3-in. (75-mm) sieve and is retained on a <sup>3</sup>/<sub>4</sub>-in. (19-mm) sieve.

fine—passes a ¾-in. (19-mm) sieve and is retained on a No. 4 (4.75-mm) sieve.

- 3.1.3 organic clay—a clay with sufficient organic content to influence the soil properties. For classification, an organic clay is a soil that would be classified as a clay, except that its liquid limit value after oven drying is less than 75 % of its liquid limit value before oven drying.
- 3.1.4 organic silt—a silt with sufficient organic content to influence the soil properties. For classification, an organic silt is a soil that would be classified as a silt except that its liquid limit value after oven drying is less than 75 % of its liquid limit value before oven drying.
- 3.1.5 peat—a soil composed primarily of vegetable tissue in various stages of decomposition usually with an organic odor, a dark brown to black color, a spongy consistency, and a texture ranging from fibrous to amorphous.
- 3.1.6 sand—particles of rock that will pass a No. 4 (4.75-mm) sieve and be retained on a No. 200 (75-µm) sieve with the following subdivisions:

coarse—passes a No. 4 (4.75-mm) sieve and is retained on a No. 10 (2.00-mm) sieve.

medium—passes a No. 10 (2.00-mm) sieve and is retained on a No. 40 (425-µm) sieve.

fine—passes a No. 40 (425- $\mu$ m) sieve and is retained on a No. 200 (75- $\mu$ m) sieve.

3.1.7 *silt*—soil passing a No. 200 (75-µm) sieve that is nonplastic or very slightly plastic and that exhibits little or no strength when air dry. For classification, a silt is a fine-grained soil, or the fine-grained portion of a soil, with a plasticity index less than 4, or the plot of plasticity index versus liquid limit falls below the "A" line (see Fig. 3 of Test Method D 2487).

#### 4. Summary of Practice

- 4.1 Using visual examination and simple manual tests, this practice gives standardized criteria and procedures for describing and identifying soils.
- 4.2 The soil can be given an identification by assigning a group symbol(s) and name. The flow charts, Fig. 1a and Fig. 1b for fine-grained soils, and Fig. 2, for coarse-grained soils, can be used to assign the appropriate group symbol(s) and name. If the soil has properties which do not distinctly place it into a specific group, borderline symbols may be used, see Appendix X3.

Note 3—It is suggested that a distinction be made between *dual symbols* and *borderline symbols*.

Dual Symbol—A dual symbol is two symbols separated by a hyphen, for example, GP-GM, SW-SC, CL-ML used to indicate that the soil has been identified as having the properties of a classification in accordance with Test Method D 2487 where two symbols are required. Two symbols are required when the soil has between 5 and 12 % fines or when the liquid limit and plasticity index values plot in the CL-ML area of the plasticity chart.

Borderline Symbol—A borderline symbol is two symbols separated by a slash, for example, CL/CH, GM/SM, CL/ML. A borderline symbol should be used to indicate that the soil has been identified as having properties that do not distinctly place the soil into a specific group (see Appendix X3).

#### 5. Significance and Use

- 5.1 The descriptive information required in this practice can be used to describe a soil to aid in the evaluation of its significant properties for engineering use.
- 5.2 The descriptive information required in this practice should be used to supplement the classification of a soil as determined by Test Method D 2487.
- 5.3 This practice may be used in identifying soils using the classification group symbols and names as prescribed in Test Method D 2487. Since the names and symbols used in this practice to identify the soils are the same as those used in Test Method D 2487, it shall be clearly stated in reports and all other appropriate documents, that the classification symbol and name are based on visual-manual procedures.
- 5.4 This practice is to be used not only for identification of soils in the field, but also in the office, laboratory, or wherever soil samples are inspected and described.
- 5.5 This practice has particular value in grouping similar soil samples so that only a minimum number of laboratory tests need be run for positive soil classification.
- Note 4—The ability to describe and identify soils correctly is learned more readily under the guidance of experienced personnel, but it may also be acquired systematically by comparing numerical laboratory test results for typical soils of each type with their visual and manual characteristics.
- 5.6 When describing and identifying soil samples from a given boring, test pit, or group of borings or pits, it is not necessary to follow all of the procedures in this practice for every sample. Soils which appear to be similar can be grouped together; one sample completely described and identified with the others referred to as similar based on performing only a few of the descriptive and identification procedures described in this practice.
- 5.7 This practice may be used in combination with Practice D 4083 when working with frozen soils.

Note 5—Notwithstanding the statements on precision and bias contained in this standard: The precision of this test method is dependent on the competence of the personnel performing it and the suitability of the equipment and facilities used. Agencies that meet the criteria of Practice D 3740 are generally considered capable of competent and objective testing. Users of this test method are cautioned that compliance with Practice D 3740 does not in itself assure reliable testing. Reliable testing depends on several factors; Practice D 3740 provides a means for evaluating some of those factors.

#### 6. Apparatus

- 6.1 Required Apparatus:
- 6.1.1 Pocket Knife or Small Spatula.
- 6.2 Useful Auxiliary Apparatus:

#### GROUP SYMBOL

#### **GROUP NAME**

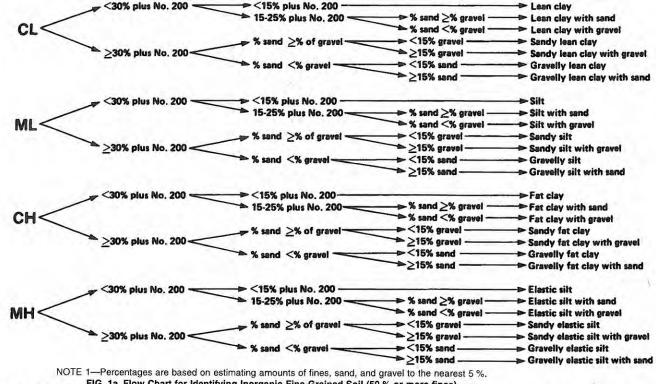


FIG. 1a Flow Chart for Identifying Inorganic Fine-Grained Soil (50 % or more fines)

#### GROUP SYMBOL

#### GROUP NAME

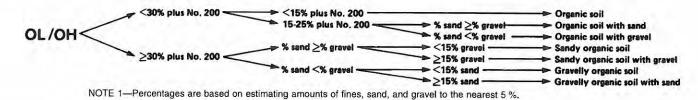


FIG. 1 b Flow Chart for Identifying Organic Fine-Grained Soil (50 % or more fines)

- 6.2.1 Small Test Tube and Stopper (or jar with a lid).
- 6.2.2 Small Hand Lens.

#### 7. Reagents

7.1 Purity of Water—Unless otherwise indicated, references to water shall be understood to mean water from a city water supply or natural source, including non-potable water.

7.2 Hydrochloric Acid—A small bottle of dilute hydrochloric acid, HCl, one part HCl (10 N) to three parts water (This reagent is optional for use with this practice). See Section 8.

#### 8. Safety Precautions

- 8.1 When preparing the dilute HCl solution of one part concentrated hydrochloric acid (10 N) to three parts of distilled water, slowly add acid into water following necessary safety precautions. Handle with caution and store safely. If solution comes into contact with the skin, rinse thoroughly with water.
  - 8.2 Caution—Do not add water to acid.

#### 9. Sampling

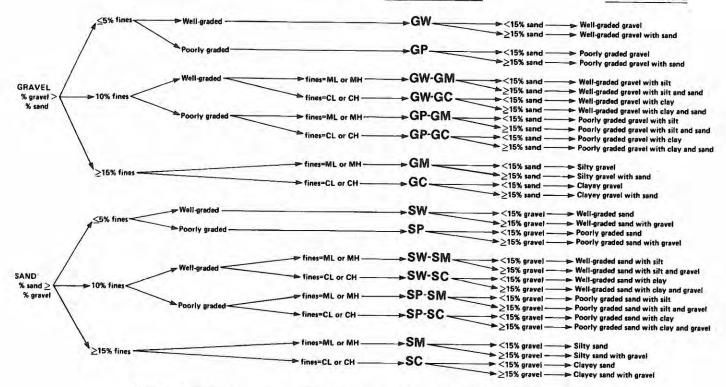
9.1 The sample shall be considered to be representative of the stratum from which it was obtained by an appropriate, accepted, or standard procedure.

Note 6-Preferably, the sampling procedure should be identified as having been conducted in accordance with Practices D 1452, D 1587, or D 2113, or Test Method D 1586.

9.2 The sample shall be carefully identified as to origin.

Note 7-Remarks as to the origin may take the form of a boring number and sample number in conjunction with a job number, a geologic stratum, a pedologic horizon or a location description with respect to a permanent monument, a grid system or a station number and offset with respect to a stated centerline and a depth or elevation.

9.3 For accurate description and identification, the minimum amount of the specimen to be examined shall be in accordance with the following schedule:



Note 1—Percentages are based on estimating amounts of fines, sand, and gravel to the nearest 5 %. FIG. 2 Flow Chart for Identifying Coarse-Grained Soils (less than 50 % fines)

Maximum Particle Size, Sieve Opening	Minimum Specimen Size, Dry Weight			
4.75 mm (No. 4)	100 g (0.25 lb)			
9.5 mm (3/s in.)	200 g (0.5 lb)			
19.0 mm (¾ in.)	1.0 kg (2.2 lb)			
38.1 mm (1½ in.)	8.0 kg (18 lb)			
75.0 mm (3 in.)	60.0 kg (132 lb)			

Note 8—If random isolated particles are encountered that are significantly larger than the particles in the soil matrix, the soil matrix can be accurately described and identified in accordance with the preceeding schedule.

9.4 If the field sample or specimen being examined is smaller than the minimum recommended amount, the report shall include an appropriate remark.

#### 10. Descriptive Information for Soils

10.1 Angularity—Describe the angularity of the sand (coarse sizes only), gravel, cobbles, and boulders, as angular, subangular, subrounded, or rounded in accordance with the criteria in Table 1 and Fig. 3. A range of angularity may be stated, such as: subrounded to rounded.

10.2 Shape—Describe the shape of the gravel, cobbles, and boulders as flat, elongated, or flat and elongated if they meet the criteria in Table 2 and Fig. 4. Otherwise, do not mention the shape. Indicate the fraction of the particles that have the shape, such as: one-third of the gravel particles are flat.

10.3 Color—Describe the color. Color is an important property in identifying organic soils, and within a given locality it may also be useful in identifying materials of similar geologic origin. If the sample contains layers or patches of

TABLE 1 Criteria for Describing Angularity of Coarse-Grained Particles (see Fig. 3)

Description	Criteria
Angular	Particles have sharp edges and relatively plane sides with unpolished surfaces
Subangular	Particles are similar to angular description but have rounded edges
Subrounded	Particles have nearly plane sides but have well-rounded corners and edges
Rounded	Particles have smoothly curved sides and no edges

varying colors, this shall be noted and all representative colors shall be described. The color shall be described for moist samples. If the color represents a dry condition, this shall be stated in the report.

10.4 Odor—Describe the odor if organic or unusual. Soils containing a significant amount of organic material usually have a distinctive odor of decaying vegetation. This is especially apparent in fresh samples, but if the samples are dried, the odor may often be revived by heating a moistened sample. If the odor is unusual (petroleum product, chemical, and the like), it shall be described.

10.5 *Moisture Condition*—Describe the moisture condition as dry, moist, or wet, in accordance with the criteria in Table 3.

10.6 HCl Reaction—Describe the reaction with HCl as none, weak, or strong, in accordance with the critera in Table 4. Since calcium carbonate is a common cementing agent, a report of its presence on the basis of the reaction with dilute hydrochloric acid is important.

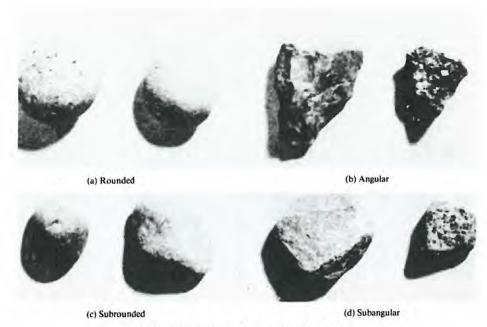


FIG. 3 Typical Angularity of Bulky Grains

#### TABLE 2 Criteria for Describing Particle Shape (see Fig. 4)

The particle shape shall be described as follows where length, width, and thickness refer to the greatest, intermediate, and least dimensions of a particle, respectively.

Flat Flongated Particles with width/thickness > 3 Particles with length/width > 3

Flat and elongated Particles meet criteria for both flat and elongated

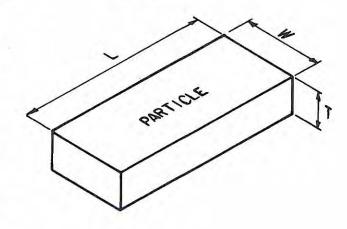
- 10.7 Consistency—For intact fine-grained soil, describe the consistency as very soft, soft, firm, hard, or very hard, in accordance with the criteria in Table 5. This observation is inappropriate for soils with significant amounts of gravel.
- 10.8 Cementation—Describe the cementation of intact coarse-grained soils as weak, moderate, or strong, in accordance with the criteria in Table 6.
- 10.9 Structure—Describe the structure of intact soils in accordance with the criteria in Table 7.
- 10.10 Range of Particle Sizes—For gravel and sand components, describe the range of particle sizes within each component as defined in 3.1.2 and 3.1.6. For example, about 20 % fine to coarse gravel, about 40 % fine to coarse sand.
- 10.11 Maximum Particle Size—Describe the maximum particle size found in the sample in accordance with the following information:
- 10.11.1 Sand Size—If the maximum particle size is a sand size, describe as fine, medium, or coarse as defined in 3.1.6. For example: maximum particle size, medium sand.
- 10.11.2 Gravel Size—If the maximum particle size is a gravel size, describe the maximum particle size as the smallest sieve opening that the particle will pass. For example, maximum particle size, 1½ in. (will pass a 1½-in. square opening but not a 3/4-in. square opening).

#### PARTICLE SHAPE

W = WIDTH

T = THICKNESS

L = LENGTH



FLAT: W/T > 3 ELONGATED: L/W >3 FLAT AND ELONGATED: -meets both criteria

FIG. 4 Criteria for Particle Shape

TABLE 3 Criteria for Describing Moisture Condition

Description	Criteria	
Dry	Absence of moisture, dusty, dry to the touch	
Moist	Damp but no visible water	
Wet	Visible free water, usually soil is below water table	

#### TABLE 4 Criteria for Describing the Reaction With HCI

Description	Criteria	
None	No visible reaction	
Weak	Some reaction, with bubbles forming slowly	
Strong	Violent reaction, with bubbles forming immediately	

#### TABLE 5 Criteria for Describing Consistency

Description	Criteria
Very soft	Thumb will penetrate soil more than 1 in. (25 mm)
Soft	Thumb will penetrate soil about 1 in. (25 mm)
Firm	Thumb will indent soil about 1/4 in. (6 mm)
Hard	Thumb will not indent soil but readily indented with thumbnail
Very hard	Thumbnail will not indent soil

#### TABLE 6 Criteria for Describing Cementation

Description	Criteria
Weak	Crumbles or breaks with handling or little finger pressure
Moderate	Crumbles or breaks with considerable finger pressure
Strong	Will not crumble or break with finger pressure

#### **TABLE 7 Criteria for Describing Structure**

Description	Criteria
Stratified	Alternating layers of varying material or color with layers at least 6 mm thick; note thickness
Laminated	Alternating layers of varying material or color with the layers less than 6 mm thick; note thickness
Fissured	Breaks along definite planes of fracture with little resistance to fracturing
Slickensided	Fracture planes appear polished or glossy, sometimes striated
Blocky	Cohesive soil that can be broken down into small angular lumps which resist further breakdown
Lensed	Inclusion of small pockets of different soils, such as small lenses of sand scattered through a mass of clay; note thickness
Homogeneous	Same color and appearance throughout

10.11.3 Cobble or Boulder Size—If the maximum particle size is a cobble or boulder size, describe the maximum dimension of the largest particle. For example: maximum dimension, 18 in. (450 mm).

10.12 Hardness—Describe the hardness of coarse sand and larger particles as hard, or state what happens when the particles are hit by a hammer, for example, gravel-size particles fracture with considerable hammer blow, some gravel-size particles crumble with hammer blow. "Hard" means particles do not crack, fracture, or crumble under a hammer blow.

10.13 Additional comments shall be noted, such as the presence of roots or root holes, difficulty in drilling or augering hole, caving of trench or hole, or the presence of mica.

10.14 A local or commercial name or a geologic interpretation of the soil, or both, may be added if identified as such.

10.15 A classification or identification of the soil in accordance with other classification systems may be added if identified as such.

#### 11. Identification of Peat

11.1 A sample composed primarily of vegetable tissue in various stages of decomposition that has a fibrous to amorphous texture, usually a dark brown to black color, and an organic odor, shall be designated as a highly organic soil and shall be identified as peat, PT, and not subjected to the identification procedures described hereafter.

#### 12. Preparation for Identification

— 12.1 The soil identification portion of this practice is based — on the portion of the soil sample that will pass a 3-in. (75-mm) sieve. The larger than 3-in. (75-mm) particles must be removed, manually, for a loose sample, or mentally, for an intact sample before classifying the soil.

12.2 Estimate and note the percentage of cobbles and the percentage of boulders. Performed visually, these estimates will be on the basis of volume percentage.

Note 9—Since the percentages of the particle-size distribution in Test Method D 2487 are by dry weight, and the estimates of percentages for gravel, sand, and fines in this practice are by dry weight, it is recommended that the report state that the percentages of cobbles and boulders are by volume.

12.3 Of the fraction of the soil smaller than 3 in. (75 mm), estimate and note the percentage, by dry weight, of the gravel, sand, and fines (see Appendix X4 for suggested procedures).

Note 10—Since the particle-size components appear visually on the basis of volume, considerable experience is required to estimate the percentages on the basis of dry weight. Frequent comparisons with laboratory particle-size analyses should be made.

12.3.1 The percentages shall be estimated to the closest 5 %. The percentages of gravel, sand, and fines must add up to 100 %.

12.3.2 If one of the components is present but not in sufficient quantity to be considered 5% of the smaller than 3-in. (75-mm) portion, indicate its presence by the term *trace*, for example, trace of fines. A trace is not to be considered in the total of 100% for the components.

#### 13. Preliminary Identification

13.1 The soil is *fine grained* if it contains 50 % or more fines. Follow the procedures for identifying fine-grained soils of Section 14.

13.2 The soil is *coarse grained* if it contains less than 50 % fines. Follow the procedures for identifying coarse-grained soils of Section 15.

#### 14. Procedure for Identifying Fine-Grained Soils

14.1 Select a representative sample of the material for examination. Remove particles larger than the No. 40 sieve (medium sand and larger) until a specimen equivalent to about a handful of material is available. Use this specimen for performing the dry strength, dilatancy, and toughness tests.

14.2 Dry Strength:

14.2.1 From the specimen, select enough material to mold into a ball about 1 in. (25 mm) in diameter. Mold the material until it has the consistency of putty, adding water if necessary.

14.2.2 From the molded material, make at least three test specimens. A test specimen shall be a ball of material about  $\frac{1}{2}$  in. (12 mm) in diameter. Allow the test specimens to dry in air, or sun, or by artificial means, as long as the temperature does not exceed  $60^{\circ}$ C.

14.2.3 If the test specimen contains natural dry lumps, those that are about ½ in. (12 mm) in diameter may be used in place of the molded balls.

Note 11—The process of molding and drying usually produces higher strengths than are found in natural dry lumps of soil.

14.2.4 Test the strength of the dry balls or lumps by crushing between the fingers. Note the strength as none, low, medium, high, or very high in accorance with the criteria in Table 8. If natural dry lumps are used, do not use the results of any of the lumps that are found to contain particles of coarse sand.

14.2.5 The presence of high-strength water-soluble cementing materials, such as calcium carbonate, may cause exceptionally high dry strengths. The presence of calcium carbonate can usually be detected from the intensity of the reaction with dilute hydrochloric acid (see 10.6).

14.3 Dilatancy:

14.3.1 From the specimen, select enough material to mold into a ball about ½ in. (12 mm) in diameter. Mold the material, adding water if necessary, until it has a soft, but not sticky, consistency.

14.3.2 Smooth the soil ball in the palm of one hand with the blade of a knife or small spatula. Shake horizontally, striking the side of the hand vigorously against the other hand several times. Note the reaction of water appearing on the surface of the soil. Squeeze the sample by closing the hand or pinching the soil between the fingers, and note the reaction as none, slow, or rapid in accordance with the criteria in Table 9. The reaction is the speed with which water appears while shaking, and disappears while squeezing.

14.4 Toughness:

14.4.1 Following the completion of the dilatancy test, the test specimen is shaped into an elongated pat and rolled by hand on a smooth surface or between the palms into a thread about ½ in. (3 mm) in diameter. (If the sample is too wet to roll easily, it should be spread into a thin layer and allowed to lose some water by evaporation.) Fold the sample threads and reroll

TABLE 8 Criteria for Describing Dry Strength

Description	Criteria	
None	The dry specimen crumbles into powder with mere pressure of handling	
Low	The dry specimen crumbles into powder with some finger pressure	
Medium	The dry specimen breaks into pieces or crumbles with considerable finger pressure	
High	The dry specimen cannot be broken with finger pressure.  Specimen will break into pieces between thumb and a hard surface	
Very high	The dry specimen cannot be broken between the thumb and a	

TABLE 9 Criteria for Describing Dilatancy

Description	Criteria
None	No visible change in the specimen
Slow	Water appears slowly on the surface of the specimen during shaking and does not disappear or disappears slowly upor squeezing
Rapid	Water appears quickly on the surface of the specimen during shaking and disappears quickly upon squeezing

repeatedly until the thread crumbles at a diameter of about ½ in. The thread will crumble at a diameter of ½ in. when the soil is near the plastic limit. Note the pressure required to roll the thread near the plastic limit. Also, note the strength of the thread. After the thread crumbles, the pieces should be lumped together and kneaded until the lump crumbles. Note the toughness of the material during kneading.

14.4.2 Describe the toughness of the thread and lump as low, medium, or high in accordance with the criteria in Table 10.

14.5 *Plasticity*—On the basis of observations made during the toughness test, describe the plasticity of the material in accordance with the criteria given in Table 11.

14.6 Decide whether the soil is an *inorganic* or an *organic* fine-grained soil (see 14.8). If inorganic, follow the steps given in 14.7.

14.7 Identification of Inorganic Fine-Grained Soils:

14.7.1 Identify the soil as a *lean clay*, CL, if the soil has medium to high dry strength, no or slow dilatancy, and medium toughness and plasticity (see Table 12).

14.7.2 Identify the soil as a *fat clay*, CH, if the soil has high to very high dry strength, no dilatancy, and high toughness and plasticity (see Table 12).

14.7.3 Identify the soil as a *silt*, ML, if the soil has no to low dry strength, slow to rapid dilatancy, and low toughness and plasticity, or is nonplastic (see Table 12).

14.7.4 Identify the soil as an *elastic silt*, MH, if the soil has low to medium dry strength, no to slow dilatancy, and low to medium toughness and plasticity (see Table 12).

Note 12—These properties are similar to those for a lean clay. However, the silt will dry quickly on the hand and have a smooth, silky feel when dry. Some soils that would classify as MH in accordance with the criteria in Test Method D 2487 are visually difficult to distinguish from lean clays, CL. It may be necessary to perform laboratory testing for proper identification.

14.8 Identification of Organic Fine-Grained Soils:

14.8.1 Identify the soil as an *organic soil*, OL/OH, if the soil contains enough organic particles to influence the soil properties. Organic soils usually have a dark brown to black color and may have an organic odor. Often, organic soils will change

TABLE 10 Criteria for Describing Toughness

Description	Criteria
Low	Only slight pressure is required to roll the thread near the plastic limit. The thread and the lump are weak and soft
Medium	Medium pressure is required to roll the thread to near the plastic limit. The thread and the lump have medium stiffness
High	Considerable pressure is required to roll the thread to near the plastic limit. The thread and the lump have very high stiffness

TABLE 11 Criteria for Describing Plasticity

Description	Criteria
Nonplastic	A 1/2-in. (3-mm) thread cannot be rolled at any water content
Low	The thread can barely be rolled and the lump cannot be formed when drier than the plastic limit
Medium	The thread is easy to roll and not much time is required to reach the plastic limit. The thread cannot be rerolled after reaching the plastic limit. The lump crumbles when drier than the plastic limit
High	It takes considerable time rolling and kneading to reach the plastic limit. The thread can be rerolled several times after reaching the plastic limit. The lump can be formed without crumbling when drier than the plastic limit

TABLE 12 Identification of Inorganic Fine-Grained Soils from Manual Tests

Soil Symbol	Dry Strength	Dilatancy	Toughness
ML	None to low	Slow to rapid	Low or thread cannot be formed
CL	Medium to high	None to slow	Medium
MH	Low to medium	None to slow	Low to medium
CH	High to very high	None	High

color, for example, black to brown, when exposed to the air. Some organic soils will lighten in color significantly when air dried. Organic soils normally will not have a high toughness or plasticity. The thread for the toughness test will be spongy.

Note 13—In some cases, through practice and experience, it may be possible to further identify the organic soils as organic silts or organic clays, OL or OH. Correlations between the dilatancy, dry strength, toughness tests, and laboratory tests can be made to identify organic soils in certain deposits of similar materials of known geologic origin.

14.9 If the soil is estimated to have 15 to 25 % sand or gravel, or both, the words "with sand" or "with gravel" (whichever is more predominant) shall be added to the group name. For example: "lean clay with sand, CL" or "silt with gravel, ML" (see Fig. 1a and Fig. 1b). If the percentage of sand is equal to the percentage of gravel, use "with sand."

14.10 If the soil is estimated to have 30 % or more sand or gravel, or both, the words "sandy" or "gravelly" shall be added to the group name. Add the word "sandy" if there appears to be more sand than gravel. Add the word "gravelly" if there appears to be more gravel than sand. For example: "sandy lean clay, CL", "gravelly fat clay, CH", or "sandy silt, ML" (see Fig. 1a and Fig. 1b). If the percentage of sand is equal to the percent of gravel, use "sandy."

## 15. Procedure for Identifying Coarse-Grained Soils (Contains less than 50 % fines)

15.1 The soil is a *gravel* if the percentage of gravel is estimated to be more than the percentage of sand.

15.2 The soil is a *sand* if the percentage of gravel is estimated to be equal to or less than the percentage of sand.

15.3 The soil is a *clean gravel* or *clean sand* if the percentage of fines is estimated to be 5 % or less.

15.3.1 Identify the soil as a *well-graded gravel*, GW, or as a *well-graded sand*, SW, if it has a wide range of particle sizes and substantial amounts of the intermediate particle sizes.

15.3.2 Identify the soil as a *poorly graded gravel*, GP, or as a *poorly graded sand*, SP, if it consists predominantly of one

size (uniformly graded), or it has a wide range of sizes with some intermediate sizes obviously missing (gap or skip graded).

15.4 The soil is either a gravel with fines or a sand with fines if the percentage of fines is estimated to be 15 % or more.

15.4.1 Identify the soil as a *clayey gravel*, GC, or a *clayey sand*, SC, if the fines are clayey as determined by the procedures in Section 14.

15.4.2 Identify the soil as a *silty gravel*, GM, or a *silty sand*, SM, if the fines are silty as determined by the procedures in Section 14.

15.5 If the soil is estimated to contain 10 % fines, give the soil a dual identification using two group symbols.

15.5.1 The first group symbol shall correspond to a clean gravel or sand (GW, GP, SW, SP) and the second symbol shall correspond to a gravel or sand with fines (GC, GM, SC, SM).

15.5.2 The group name shall correspond to the first group symbol plus the words "with clay" or "with silt" to indicate the plasticity characteristics of the fines. For example: "well-graded gravel with clay, GW-GC" or "poorly graded sand with silt, SP-SM" (see Fig. 2).

15.6 If the specimen is predominantly sand or gravel but contains an estimated 15 % or more of the other coarse-grained constituent, the words "with gravel" or "with sand" shall be added to the group name. For example: "poorly graded gravel with sand, GP" or "clayey sand with gravel, SC" (see Fig. 2).

15.7 If the field sample contains any cobbles or boulders, or both, the words "with cobbles" or "with cobbles and boulders" shall be added to the group name. For example: "silty gravel with cobbles, GM."

#### 16. Report 🛞

16.1 The report shall include the information as to origin, and the items indicated in Table 13.

Note 14—Example: Clayey Gravel with Sand and Cobbles, GC—About 50 % fine to coarse, subrounded to subangular gravel; about 30 % fine to coarse, subrounded sand; about 20 % fines with medium plasticity, high dry strength, no dilatancy, medium toughness; weak reaction with HCl; original field sample had about 5 % (by volume) subrounded cobbles, maximum dimension, 150 mm.

In-Place Conditions-Firm, homogeneous, dry, brown

Geologic Interpretation-Alluvial fan

Note 15—Other examples of soil descriptions and identification are given in Appendix X1 and Appendix X2.

Note 16—If desired, the percentages of gravel, sand, and fines may be stated in terms indicating a range of percentages, as follows:

Trace-Particles are present but estimated to be less than 5 %

Few-5 to 10 %

Little-15 to 25 %

Some-30 to 45 %

Mostly-50 to 100 %

 $16.2\,$  If, in the soil description, the soil is identified using a classification group symbol and name as described in Test Method D 2487, it must be distinctly and clearly stated in log forms, summary tables, reports, and the like, that the symbol and name are based on visual-manual procedures.

#### 17. Precision and Bias

17.1 This practice provides qualitative information only, therefore, a precision and bias statement is not applicable.



#### TABLE 13 Checklist for Description of Soils

- 1. Group name
- 2. Group symbol
- 3. Percent of cobbles or boulders, or both (by volume)
- 4. Percent of gravel, sand, or fines, or all three (by dry weight)
- 5. Particle-size range:

#### Gravel—fine, coarse

Sand-fine, medium, coarse

- 6. Particle angularity: angular, subangular, subrounded, rounded
- 7. Particle shape: (if appropriate) flat, elongated, flat and elongated
- 8. Maximum particle size or dimension
- 9. Hardness of coarse sand and larger particles
- 10. Plasticity of fines: nonplastic, low, medium, high
- 11. Dry strength: none, low, medium, high, very high
- 12. Dilatancy: none, slow, rapid
- 13. Toughness: low, medium, high
- 14. Color (in moist condition)
- 15. Odor (mention only if organic or unusual)
- 16. Moisture: dry, moist, wet
- 17. Reaction with HCl: none, weak, strong
- For intact samples:
- 18. Consistency (fine-grained soils only): very soft, soft, firm, hard, very hard
- Structure: stratified, laminated, fissured, slickensided, lensed, homogeneous
- 20. Cementation: weak, moderate, strong
- 21. Local name
- 22. Geologic interpretation
- 23. Additional comments: presence of roots or root holes, presence of mica, gypsum, etc., surface coatings on coarse-grained particles, caving or sloughing of auger hole or trench sides, difficulty in augering or excavating, etc.

#### 18. Keywords

18.1 classification; clay; gravel; organic soils; sand; silt; soil classification; soil description; visual classification

#### APPENDIXES

#### (Nonmandatory Information)

#### X1. EXAMPLES OF VISUAL SOIL DESCRIPTIONS

- X1.1 The following examples show how the information required in 16.1 can be reported. The information that is included in descriptions should be based on individual circumstances and need.
- X1.1.1 Well-Graded Gravel with Sand (GW)—About 75 % fine to coarse, hard, subangular gravel; about 25 % fine to coarse, hard, subangular sand; trace of fines; maximum size, 75 mm, brown, dry; no reaction with HCl.
- X1.1.2 Silty Sand with Gravel (SM)—About 60 % predominantly fine sand; about 25 % silty fines with low plasticity, low dry strength, rapid dilatancy, and low toughness; about 15 % fine, hard, subrounded gravel, a few gravel-size particles fractured with hammer blow; maximum size, 25 mm; no reaction with HCl (Note—Field sample size smaller than recommended).
- In-Place Conditions—Firm, stratified and contains lenses of silt 1 to 2 in. (25 to 50 mm) thick, moist, brown to gray; in-place density 106 lb/ft<sup>3</sup>; in-place moisture 9 %.

- X1.1.3 Organic Soil (OL/OH)—About 100% fines with low plasticity, slow dilatancy, low dry strength, and low toughness; wet, dark brown, organic odor; weak reaction with HCl.
- X1.1.4 Silty Sand with Organic Fines (SM)—About 75 % fine to coarse, hard, subangular reddish sand; about 25 % organic and silty dark brown nonplastic fines with no dry strength and slow dilatancy; wet; maximum size, coarse sand; weak reaction with HCl.
- X1.1.5 Poorly Graded Gravel with Silt, Sand, Cobbles and Boulders (GP-GM)—About 75 % fine to coarse, hard, subrounded to subangular gravel; about 15 % fine, hard, subrounded to subangular sand; about 10 % silty nonplastic fines; moist, brown; no reaction with HCl; original field sample had about 5 % (by volume) hard, subrounded cobbles and a trace of hard, subrounded boulders, with a maximum dimension of 18 in. (450 mm).

## X2. USING THE IDENTIFICATION PROCEDURE AS A DESCRIPTIVE SYSTEM FOR SHALE, CLAYSTONE, SHELLS, SLAG, CRUSHED ROCK, AND THE LIKE

- X2.1 The identification procedure may be used as a descriptive system applied to materials that exist in-situ as shale, claystone, sandstone, siltstone, mudstone, etc., but convert to soils after field or laboratory processing (crushing, slaking, and the like).
- X2.2 Materials such as shells, crushed rock, slag, and the like, should be identified as such. However, the procedures used in this practice for describing the particle size and plasticity characteristics may be used in the description of the material. If desired, an identification using a group name and symbol according to this practice may be assigned to aid in describing the material.
- X2.3 The group symbol(s) and group names should be placed in quotation marks or noted with some type of distinguishing symbol. See examples.
- X2.4 Examples of how group names and symbols can be incororated into a descriptive system for materials that are not naturally occurring soils are as follows:

- X2.4.1 Shale Chunks—Retrieved as 2 to 4-in. (50 to 100-mm) pieces of shale from power auger hole, dry, brown, no reaction with HCl. After slaking in water for 24 h, material identified as "Sandy Lean Clay (CL)"; about 60 % fines with medium plasticity, high dry strength, no dilatancy, and medium toughness; about 35 % fine to medium, hard sand; about 5 % gravel-size pieces of shale.
- X2.4.2 Crushed Sandstone—Product of commercial crushing operation; "Poorly Graded Sand with Silt (SP-SM)"; about 90 % fine to medium sand; about 10 % nonplastic fines; dry, reddish-brown.
- X2.4.3 Broken Shells—About 60 % uniformly graded gravel-size broken shells; about 30 % sand and sand-size shell pieces; about 10 % nonplastic fines; "Poorly Graded Gravel with Silt and Sand (GP-GM)."
- X2.4.4 Crushed Rock—Processed from gravel and cobbles in Pit No. 7; "Poorly Graded Gravel (GP)"; about 90 % fine, hard, angular gravel-size particles; about 10 % coarse, hard, angular sand-size particles; dry, tan; no reaction with HCl.

## X3. SUGGESTED PROCEDURE FOR USING A BORDERLINE SYMBOL FOR SOILS WITH TWO POSSIBLE IDENTIFICATIONS.

- X3.1 Since this practice is based on estimates of particle size distribution and plasticity characteristics, it may be difficult to clearly identify the soil as belonging to one category. To indicate that the soil may fall into one of two possible basic groups, a borderline symbol may be used with the two symbols separated by a slash. For example: SC/CL or CL/CH.
- X3.1.1 A borderline symbol may be used when the percentage of fines is estimated to be between 45 and 55 %. One symbol should be for a coarse-grained soil with fines and the other for a fine-grained soil. For example: GM/ML or CL/SC.
- X3.1.2 A borderline symbol may be used when the percentage of sand and the percentage of gravel are estimated to be about the same. For example: GP/SP, SC/GC, GM/SM. It is practically impossible to have a soil that would have a borderline symbol of GW/SW.
- X3.1.3 A borderline symbol may be used when the soil could be either well graded or poorly graded. For example: GW/GP, SW/SP.
- X3.1.4 A borderline symbol may be used when the soil could either be a silt or a clay. For example: CL/ML, CH/MH, SC/SM.

- X3.1.5 A borderline symbol may be used when a finegrained soil has properties that indicate that it is at the boundary between a soil of low compressibility and a soil of high compressibility. For example: CL/CH, MH/ML.
- X3.2 The order of the borderline symbols should reflect similarity to surrounding or adjacent soils. For example: soils in a borrow area have been identified as CH. One sample is considered to have a borderline symbol of CL and CH. To show similarity, the borderline symbol should be CH/CL.
- X3.3 The group name for a soil with a borderline symbol should be the group name for the first symbol, except for:

CL/CH lean to fat clay ML/CL clayey silt CL/ML silty clay

X3.4 The use of a borderline symbol should not be used indiscriminately. Every effort shall be made to first place the soil into a single group.

## X4. SUGGESTED PROCEDURES FOR ESTIMATING THE PERCENTAGES OF GRAVEL, SAND, AND FINES IN A SOIL SAMPLE

- X4.1 Jar Method—The relative percentage of coarse- and fine-grained material may be estimated by thoroughly shaking a mixture of soil and water in a test tube or jar, and then allowing the mixture to settle. The coarse particles will fall to the bottom and successively finer particles will be deposited with increasing time; the sand sizes will fall out of suspension in 20 to 30 s. The relative proportions can be estimated from the relative volume of each size separate. This method should be correlated to particle-size laboratory determinations.
- X4.2 Visual Method—Mentally visualize the gravel size particles placed in a sack (or other container) or sacks. Then, do the same with the sand size particles and the fines. Then, mentally compare the number of sacks to estimate the percentage of plus No. 4 sieve size and minus No. 4 sieve size present.

The percentages of sand and fines in the minus sieve size No. 4 material can then be estimated from the wash test (X4.3).

- X4.3 Wash Test (for relative percentages of sand and fines)—Select and moisten enough minus No. 4 sieve size material to form a 1-in (25-mm) cube of soil. Cut the cube in half, set one-half to the side, and place the other half in a small dish. Wash and decant the fines out of the material in the dish until the wash water is clear and then compare the two samples and estimate the percentage of sand and fines. Remember that the percentage is based on weight, not volume. However, the volume comparison will provide a reasonable indication of grain size percentages.
- X4.3.1 While washing, it may be necessary to break down lumps of fines with the finger to get the correct percentages.

#### X5. ABBREVIATED SOIL CLASSIFICATION SYMBOLS

- X5.1 In some cases, because of lack of space, an abbreviated system may be useful to indicate the soil classification symbol and name. Examples of such cases would be graphical logs, databases, tables, etc.
- X5.2 This abbreviated system is not a substitute for the full name and descriptive information but can be used in supplementary presentations when the complete description is referenced.
- X5.3 The abbreviated system should consist of the soil classification symbol based on this standard with appropriate lower case letter prefixes and suffixes as:

Prefix:	Suffix:
s = sandy	s = with sand
g = gravelly	g = with gravel
	c = with cobbles
	h - with houlders

X5.4 The soil classification symbol is to be enclosed in parenthesis. Some examples would be:

Group Symbol and Full Name	Abbreviated
CL, Sandy lean clay	s(CL)
SP-SM, Poorly graded sand with silt and gravel GP, poorly graded gravel with sand, cobbles, and	(SP-SM)g (GP)scb
boulders ML, gravelly silt with sand and cobbles	g(ML)sc

#### SUMMARY OF CHANGES

In accordance with Committee D18 policy, this section identifies the location of changes to this standard since the last edition (2000) that may impact the use of this standard.

(1) Revised footnote numbering in Reference Section.

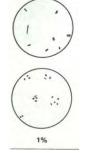
(2) Revised classification example in X2.4.2 and X2.4.3.

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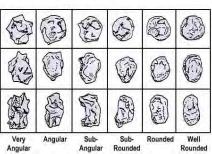
Unified Soil Classification System							USCS Sand Size System					
Well-graded gravels and gravel-sand mixtures,							4.75-2 mm					
Gravels >50% of course 75 - 4.75-mm	Clean Gravels Will not leave a	GW	<5% less fines	and mi	xtures,		Coarse		0.08"	Med Med		
	stain on wet pal		Poorly graded gravels and gravel-sand mixtures, <5% less fines			Medium 2 - 0.475 0.08 - 0		-		<b>300</b>		
3 - 0.2 Inches	Gravels w/ fines		Silty gravels, gravel-sand-silt mixtures			Fine 0.475–0.0 0.02-0.				0000		
	on wet palm	GC	Clayey gravels, gravel-sand-clay mixtures			Modified We			Ventwor	entworth Scale		
	Clean Sands	SW	Well-graded sands & gravelly sar fines	nds, <5	% less				<b>%</b>			
<b>Sands</b> < 50% course 4.75 - 0.075	Will not leave a stain on wet pal		Poorly graded sands & gravelly s less fines	very Coarse		1-2	1-2 mm					
mm	Sand w/ fines	SM	Silty sands, sand-silt mixtures									
0.2 - 0.003 Inch	Will leave a stai on wet palm	SC	Clayey sands, sand-clay mixtures	i			Coarse	0.5-	0.5-1 mm			
Consistency <sup>2</sup>			Field Test		T N vs/ft.		Medium	0.25-0	).5 mm			
Very Loose	Easily penetrated	with 1/2	in rebar pushed by hand		4		ricalani	0.23	,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,			
Loose	" "	***	w.	4-	10							
Med Dense	Penetrated a foo	with 1/	in rebar driven w/ 5 lb. hammer	10	-30	Fine 0.125-0.		).25 mm				
Dense	" "	"	" " 30-50					(海路)				
Very Dense	Only Penetrated hammer	a few in	few in w/ ½ in rebar driven w/ 5 lb.			Very Fine 0.062-0.125			.125 mm	.25 mm		
	Field Plasticity Test											
Fine-Grained Soils (Clays and Silts)  More than 50% passes the (No. 200) 0.075 mm 0.003 Inches  Shake/Tap Test  Ribbon Test  Worm / Bead Test					Dry Crushing Strength							
Silts and Liquid Lim			organic silts, very fine sands, rock t y or clayey fine sands	four, Rapid None None		Can't support 6mm dia. held on end		None - Slight				
(Non-Plastic Plasti			organic clays of low to medium planavelly/sandy/silty/lean clays	sticity,		e –V ow	Med.	Weak		a. held on end	Med - Hi	
Silts and	Clays		organic silts, micaceous or diatoma e sands or silts, elastic silts	ceous	Slow-	-None	Low	Strong	4 mm dia end	. held on	Slight – Med.	
Liquid Lim (Med to High	- DI+:-)	H Ind	organic clays or high plasticity, fat	clays	No	ne	Very Hi	V Strong	2 mm dia. held on end		High – V Hi	
High Organ	nic Soils (	L Or	ganic silts and organic silty clays o	low pl	asticity	(See M	L and CL pla	sticity above	:)		1	
Readily identified odor, spongy		H Or	ganic clays of medium to high plas	ticity								
frequently by fib		Peat, muck, and other highly organic soils										
Consistency <sup>2</sup>		Field Test SPT N Blows/ft. Penetrometer										
Very Soft	Easily penetrated several inches by thumb. Exudes between fingers when squeezed in hand.											
Soft	Soft Easily penetrated one inches by thumb. Molded by light pressure. 2-4 500-1000						500-1000					
Med Stiff	ed Stiff Can be penetrated 1/4" by thumb w/ moderate effort. Molded by strong pressure. 4-8 1000-2000					1000-2000						
Stiff	Indented 1/4	lented 1/4 in by thumb but penetrated w/ great effort. 8-15 2000-4000										
Very Stiff	Readily indent	Readily indented with thumbnail. 15-30 4000-8000					4000-8000					
Hard	Hard Indented with difficulty by thumbnail. >30 >8000						>8000					
( )	( )	3										











High
Sphericity
Medium
Sphericity

Low
Sphericity

ENS/IFE	Sketch of Boring Location	Location ID:
		of
Olivet		Start Date/Time:
Client:		End Date/Time: Total Depth:
Project #:		Sample Method:
Purpose:		Drill Equip:
Project:		Drilling Co.:
Location:		Geologist:
Inches Recovered Inches Recovered Inches Inc	Lithologic Des	
Number Interval Interval Inches Recovered Inches In	Visual-Manual De	
Miss Record of the last of the	(ASTM D 24	488-06)
0-		
1-		
2-		
3-		
4-		
5-		
/   /		
6-		
7-		
/   /		
8-		
9-		
/   /		
0-		
/		
2-		
3-		
4-		
5-		
6-1		
7		
8-		
/   /         "   "		
9-		

Notes:	Well Constu	iction	Тор	Base	Sample ID	Time	Interval	Analyses
	Material:	Casing:			1)			
	Diameter:	Screen:			2)			
	Wellhead:	Grount:			3)			
	Ballards:	Bent/Seal:			4)			
	Pad:	Sand Pack:			5)			

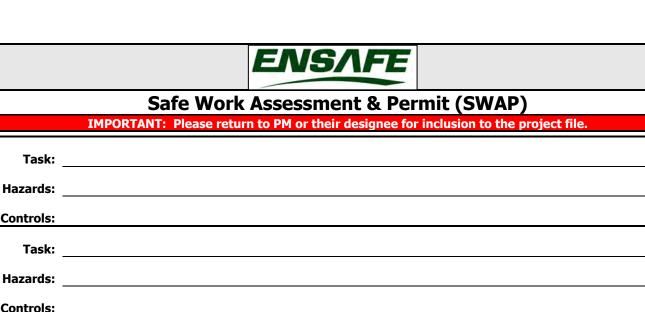


#### Safe Work Assessment & Permit (SWAP)

	or their designee for inclusion to the project file.						
Section 1: Project Information							
Project/Client Name:	SWAP Date/Time:						
Location of the Work:							
Description of Work:	Project Number:						
Has a HASP been created for this job? Yes No	If Yes, has the HASP been reviewed prior to work?  Yes No						
·	, = =						
Section 2: Mobilization and Demobilization Safety	Yes No Yes No						
Is vehicle in safe operating condition	Has distracted driving been discussed						
13 verifice in sure operating condition							
Section 3: Identify hazards associated with tasks a	and tools <u>FOR THIS DAY</u>						
Critical Safety Tasks are listed below. (If answer	red "Yes" please call Corporate H&S for additional guidance/checks)						
	Yes No Yes No						
Performing work in confined spaces or excavations	☐ Use of respiratory protection ☐ ☐						
Hazardous chemical exposure	☐ ☐ Involvement with lockout/tagout activities ☐ ☐						
Falls greater than six (6) feet	Trenching or excavation (has Subsurface Utility						
-	— Checklist been completed)						
Hot work (open flames, sparking tools, sparks, etc.)	☐ ☐ Drilling or subsurface sampling ☐ ☐						
Section 4: Chemical Hazards and PPE							
	Yes No Yes No						
Radiation or other contamination	Environmental toxin						
Flammable/combustible materials or vapors (<140°F FP)	Reactive, volatile, or explosive						
RCRA hazardous materials (listed or characteristic)	☐ ☐ Irritant or sensitizer ☐ ☐						
Corrosive	Oxidizer						
Poison, target organ toxin	☐ ☐ Teratogen or mutagen ☐ ☐						
Biological (mold, poison oak-ivy-sumac, snakes, etc.)	☐ ☐ Carcinogen ☐ ☐						
Routes of Exposure:	Vac Na						
Inhalation	Yes No Yes No Yes No ☐ Ingestion (poor hygiene and work practice) ☐ ☐						
Skin (dermal absorp) or mucus membranes (eyes, etc.)	☐ ☐ Injection (rare) ☐ ☐						
Personal Protective Equipment (PPE) FOR THIS DAY	<u>Y</u>						
Level of protection A B							
Respiratory protection	☐ Half face ☐ Cartridge type: ☐ Protective suit ☐ High-visibility vest/shirt						
Gloves None Nitrile But							
Footware None Steel-toe leather							
Eye/fact protection	☐ Face shield ☐ Chemical goggles ☐ Bump cap ☐ Other:						
Hearing protection None Ear plugs	☐ Muffs ☐ Combination (list)						
Section 5: Physical Hazards and Controls:	, ,						

On the following page, list each task not previously discussed that presents hazards, and identify controls you will take to minimize risk. Following is a non-inclusive list of potential hazards.

- AWW Jotentially unsafe area or neighborhood
- AWWY orking around high noise (> 85 dBA)
- Activities that require coring or drilling
- Drilling around underground utilities
- Remote location w/ limited communication
- Working around heavy equipment/traffic
- Working in proximity to deep water (>3 ft)
- Work with equipment around power lines
- Slick, uneven walking/working surfaces
- Climbing ladders/scaffolds
- Using gas or propane powered equipment in enclosed areas
- Work in extreme heat (> 100° F) or extreme cold (<30° F)
- Power tools (hammer drills, auger, etc.)
- Working with lifting/hoisting equipment
- Vehicular traffic, fork lifts, scissors lifts
- Inclement weather (lightning, high winds)
  - Work with ergonomic hazards (lifting hazards, twisting, excessive repetitive)



Controls:					
Section 6: Emergency Contact Information					
Name: Project Manager	Name:				
Number(s):	Numbers:				
Name: EnSafe HR – Heather Collins	Name: EnSafe Corporate Health and Safety – John Knopf				
<b>Number(s):</b> 901-937-4366 (Office) <b>Number(s):</b> 901-937-4255 (Office) or 901-451-1464 (Cell)					
Section 7: SWAP Review and Certification (All EnSafe Team Members)					

Hazards:

Controls:

Controls:

Section 7: SWAP Review and Certification (All EnSafe Team Members)							
Printed Name	Company	Signature	Date				

SWAP Comp	leted By: Print	SWAP C	ompleted By: Sign	PM Revie	w (Initials)
personnial ori and justices	changes in ecope of morn	or north contains that, requ			,
personnel on the jobsite.	Changes in scope of work	or work conditions may requ	ire the modification of exist	ing SWAP or creation of a r	iew SWAP.

THE LOCATION WHERE THE WORK IS TO BE DONE HAS BEEN EXAMINED AND NECESSARY PRECAUTIONS TAKEN FOR THE WORK. I certify that the above-listed project has been evaluated for hazards and personal protective measures assigned and communicated with all EnSafe

Contact EnSafe Corporate H&S if you have any questions.



#### PRE-DRILLING/EXCAVATION UTILITY CHECKLIST (COMPLETE IN ADDITION TO THE SWAP)

Site Name & Address:	(1)		
EnSafe Project Number & Man	<del>_</del>		
Project Manager Signature	e AFTER fieldwork has been completed:		
	ng planning stages (B)=To be accomplished onsite before fieldwork activities.	ities	
	UBLIC AND PRIVATE PROPERTY) REQUIREMENTS	YES	NO
1(A). Has the "State-Specif	fic One Call" been notified to mark the locations of all underground if Fieldwork is Extended Past 2 Weeks After Inquiry.		
<b>2(A).</b> One-Call Ticket Info.			
(REQUIRED BY LAW)			
	Beginning & Expiration Date/Time:		
	Entities to be contacted separately:		
-			
3(A&R) Have facility (and c	other relevant) personnel been interviewed and asked to provide copies		
	ms and drawings about underground utilities near the excavation area?		
	rough been accomplished to identify surface indicators of utilities?		
	ions of underground utilities been marked on the surface by one-call	]	]
	ield personnel understand how these utilities traverse underground?		
<b>6(A&amp;B).</b> Have the locations	of utilities been inserted on the work area drawing(s)?		
<b>7(B).</b> Has all available info	ormation concerning the type/location/depth of known underground		
	responsible supervisor or contractor at the work site for review and		
possible offset/relocation?			
been used to confirm positio	and pipe locating devices (PM/Qualified Safety Review approval)		
	ols (hand auger and/or equivalent technology) been used to dig trial		
	of 5 FEET below ground surface AND ideally to include the		
	ownhole sampling tool, including any surficial materials) to		
	oth of the underground utilities, or to determine that utilities are not		
	ion? Depending on regional subsurface (Depth of Frost in NE part of U		
	s may be buried deeper than 5 feet. All modifications regarding assume	ed dept	:h
	Field Notes/Concerns section on the next page.		- 4-1
	evation (at all times), a watch is kept for evidence of cables, piper not previously identified.	es, or	otner
NLY			
§ o   11(B). If heavy equ	uipment is required to cross an area where underground utilities are	known	to be
present, the cross po	ints are kept to a minimum and are clearly marked.		
<ul><li>— Please refer to the ba</li></ul>	ck of this form for explanations and tips on how to answer the question	s listed	above
	f this checklist for comments/concerns to any of these questions and		
=	ewer (listed on the EnSafe Intranet) for the specific State/Region the	at field	lwork is
performed.			
A Qualified Cafety	Deviewer MUCT he consulted and approve this site enesitie (		EFOR
	Reviewer MUST be consulted and approve this site-specific fumence if the answer to ANY Question on the checklist is NO		
	Email/In Person) is possible prior to starting work operations, but advar		
	reviewer time to look at maps/drawings of the site and all other relevant		
•	1,7		
Checklist Submitted By:	Qualified Safety Review (I	f Need	<u>led):</u>
Name:	Name:		
Signature:	Signature:		
Date:	Date:		

Revised August 28, 2015



#### PRE-DRILLING/EXCAVATION UTILITY CHECKLIST (EXPLANATIONS AND TIPS)

The instructions below have been developed to assist field personnel in accomplishing the tasks on the front of this form. If at any time field personnel are unclear on how to perform these necessary pre-job steps, refer to the Qualified Safety Reviewer list on the EnSafe Intranet.

(A)=To be accomplished during planning stages (B)=To be accomplished onsite before fieldwork activities

#### **UNDERGROUND UTILITIES (PUBLIC AND PRIVATE PROPERTY)**

**1(A).** This is REQUIRED no matter if the work area is on public or private property. Borings/excavations should be located onsite before One-Call notification, if possible, with WHITE paint/flagging. **Update One-Call every 2 weeks, and locators need 3 working days to mark all utilities within the work area.** 

**2(A).** This may be accomplished by telephone/internet. Most state-specific one-call agencies are open 8AM-5PM local time, Monday thru Friday.

**3(A&B).** This may happen the morning of the drilling/excavation activities to be performed. All personnel need to be aware of underground utilities within (or near) the work area. Offsets may be performed to minimize the probability of encountering underground utilities.

**4(B).** Example: light posts, valve pits, pit covers, curb/gutter inlets, manholes, surface indentations, saw cut areas, etc. This is best performed during the pre-bid site visit, but may be performed immediately before activities.

**5(B).** One-Call color markings typically are as follows: WHITE (Excavation/Borings), RED (Power/Electrical), YELLOW (Gas/Petroleum), ORANGE (Communication/Fiber Optics), BLUE (Potable Water), GREEN (Sanitary/Storm Sewer). Review all colors and positions with field personnel prior to beginning drilling/excavating.

**6(A&B).** This refers to simply looking at the underground utilities onsite and plotting them (by hand initially) on the site drawing or aerial.

**7(B).** If NO, please explain. After all underground utilities have been plotted on the drawing, review the locations with the EnSafe PM, all personnel (including subcontractors), and the client if deemed necessary. This will help to orient all field personnel as to the location of the underground utilities within or near work operations. If the utilities are marked within a 3 horizontal feet lateral distance of the boring/excavation, offsets SHOULD be considered.

**8(B).** This refers to the use of a private utility locator to assist in locating underground utilities on private property that haven't been located by the One-Call system. This is highly dependent upon the makeup of the underground utility (metal, plastic, clay terra cotta, etc.) and complications due to rebar within concrete, multiple utilities crossing points, etc. Only previously trained personnel (most likely private utility locator and/or geophysical subcontractors) should use these devices. The Qualified Safety Reviewer AND the EnSafe PM AND the client will make the decision TOGETHER if a private utility locator is required.

**9(B).** Example — hand augers, probe rod, vacuum extraction, air knife, post-hoe digger, etc. This is NON-NEGOTIABLE for drilling activities. Every boring must be advanced (without mechanical means) to a depth of five (5) feet below ground surface (or maximum boring depth if boring terminal depth is less than 5 feet). Only exception is where large boulder or bedrock in within the top 5 feet of the boring. Boring may be halted at a depth less than 5 feet if it is confirmed and documented that the boring is blocked by rock with apparent diameter greater than that of the boring/trial hole.

(CAVATION

**10(B).** This is site-specific, but usually no closer than 3 horizontal feet from any and all underground utilities (especially lines with high pressure or voltage/flammable/combustible substances). The safe distance for overhead utilities is 10 horizontal - 10 vertical feet (up to 50kV). Stay alert at all times. All personnel (EnSafe and Subcontractors) have stop work authority in reference to underground utilities. No job is too important to compromise safety.

**11(B).** The depth/alignment of the underground utility to be crossed should be determined to prevent damage to each buried utility.

#### Insert Field Notes/Concerns Here:



#### **Subsurface Utility Location Team Members**

Memphis, TN – Wesley Goodnight, Dave Fuehrer, Joe Matthews, Jason Broughton, Ben Brantley

Nashville, TN – Tammy Keim-Williams, Greg Olin, Troy Estes

Knoxville, TN – Brian Caldwell, Jerry Truitt, Lance Green

Charleston, SC – David Warren, Chad Tripp

Bowling Green, KY – David Doyle, Ric Federico

Cincinnati, OH – Jim Rathbone

Cleveland, OH – Ned Baker, Wendy Zayac

Dallas, TX – Tom Wiberg, Jay Spence

Hartford, CT – Glen Bianchi, Rob McCarthy

Londonderry, NH – Robert Francis

Jackson, MS - Brian Derry, Kirk Giessinger

Pleasant Hill, CA – Josh Teves, Maulik Bavishi

Jacksonville, FL – Frank McInturff, David Myers

Additional Corporate Resources – Paul Stoddard, Jeff James, John Knopf



#### **Well Construction Form**

Facility/Project Name:	Well ID.:
Facility License Number:	Type of Well:  Ground Water Monitoring  Piezometer ☐ Injection ☐  Other
Date Well Installed:	Location of well relative to waste source:
Well Installed By:	Upgradient Downgradient Side-gradient Unknown
	Well Driller License Number:
Geologist:	1. Cap and lock?  Yes No
A. Protective pipe: ft. above grade	2. Protective cover pipe:
B. Well casing, top elevation: ft. MSL	a. Inside diameter: in.
C. Land Surface Elevation: ft. MSL	b. Length: ft.
D. Surface seal, bottom: ft.below grade	c. Material: Steel ☐ Other
12. USCS classification of soil near screen:	3. Surface seal: Bentonite  Concrete
GP□ GM □ GC □ GW □ SP □ SM □	Other:
SC SW ML MH CL CH	4. Material blw. well casing and protective pipe:
Bedrock   13.6:	Bentonite ☐ Annular space seal ☐
13. Sieve analysis attached? Yes ☐ No ☐ 14. Drilling method used: Rotary ☐ HSA ☐	Other:
Other:	5. Annular space seal: (Manufacturer name)
15. Drilling fluid used:	a. Granular bentonite
Water ☐ Air ☐ Drilling Mud ☐ None ☐	b. Bentonite/Cement slurry
16. Drilling additives used? Yes ☐ No ☐ Specify:	% bentonite Bentonite/cement grout Lbs/gal mud weight bentonite slurry
17: Source of water:	c. How installed: Tremie   Tremie pumped
E. Bentonite seal: top ft. (depth)	Gravity□
	6. Bentonite seal: (Manufacturer, product name)
F. Fine sand: top ft. (depth)	Bentonite granules
G. Filter pack: top ft. (depth)	□ ¼ in. □ 3/8 in. □ ½ in. Bentonite pellets □
H. Screen joint top: ft. (depth)	Other:
I. Well bottom: ft. (depth)	7. Fine sand material: (Manufacturer, product name, mesh size) Volume added: ft <sup>3</sup>
J. Filter pack: bottom ft. (depth)	
K. Borehole: bottom . ft.( depth)	8. Filter pack material: (Manufacturer, product name, mesh size)
Borehole diameter: in.	Volume added: ft <sup>3</sup>
	9. Well casing: Flush-threaded Sch 40 PVC
	Flush-threaded Sch 80 PVC
	Other:
CERTIFICATION: I hereby certify that the information on this form is true	10. Screen material:
and correct to the best of my knowledge:	a. Screen type: factory cut □ continuous slot □
	Other:
(Signature)	b. Manufacturer:
	c. Slot size: 0. in.
(Company Name)	d. Slotted length: ft.
	V11. Backfill material: or None □

ENSAFE													
	V	VELL D	EVELOF	PMENT 8	GROU	NDWATE	RSAMP	LING FO	ORM				
DATE:				JOB NUMBER: PH			PHASE:	PHASE: TASK:					
PROJECT:				EVENT:									
WELL ID:			LOCATI	ON:									
WEATHER CONDITIONS	S:				AMBIEN	IT TEMP:							
REVIEWED BY:					PERSOI	PERSONNEL:							
WELL DIA:						WELL DEVELOPMENT							
TOTAL DEPTH from TO	C (ft.):				START:				FINISH:				
DEPTH TO WATER from	TOC (ft.):				VOLUME PURGED (gal):								
LENGTH OF WATER CO	)L. (ft.):						GROU	INDWAT	ER SAM	PLING			
1 VOLUME OF WATER (	gal):				START:				FINISH:				
3 VOLUMES OF WATER	(gal):				VOLUM	E PURGE	) (gal):						
					ANALYS	SIS:							
MNA FIELD RESULT	s												
FERROUS IRON		mg/L	CHLORII	DE			mg/L					mg/L	
SULFIDE		mg/L	ALKALIN	IITY			mg/L					mg/L	
SULFATE		mg/L	CO <sub>2</sub>				mg/L					mg/L	
IN-SITU TESTING		l l											
Circle one: DEVELO	PMENT	SAMI	PLING			□ Bailer	□ Pump	De	scription:				
Time (hh:mm):		0,											
pH (units):													
Conductivity (mS/cm):													
Turbidity (NTU):													
DO (mg/L): Horiba													
YSI													
Temperature (C°):													
ORP (mV):													
Volume Purged (gal):													
Depth to Water (ft):													
Orion ORP: mV													
E <sub>H</sub>													
Rel mV													
								We	II Goes D	ry While	Purging		
SAMPLE DATA							□ Pump		scription:				
Sample ID				me Bottles :mm) (total to lab)		Filtered (0.45 mm)			Remarks				
Purging/Sampling Devic	e Decon Pi	rocess:											
COMMENTS:													
Purge water placed in dr	Purge water placed in drum#												

Appendix B
EnSafe Standard Operating Procedures

#### Standard Operating Procedure Underground Utilities

These standards will ensure continuity within the organization.

#### **Preamble**

This standard operating procedure (SOP) is designed to provide the user standards on instituting measures to ensure underground utilities have been marked before intrusive work begins. This is a health and safety measure and should be part of the health and safety and sampling and analysis plans.

Before using this SOP and as part of the due diligence, the user is required to check if local, state, and federal rules/guidance apply to determining the presents of underground utilities. If a difference exists between local, state, and federal SOPs then those contained herein, the local, state, and federal SOPs takes precedent. If this SOP is modified per agreement between parties associated with the activity, the agreed changes will become part of the SOP and the modifications will be appended to this SOP for the record.

#### 1.0 PURPOSE AND SCOPE

The purpose of this SOP is to provide the user(s) guidance on steps required in identifying underground utilities before any intrusive subsurface work begins.

This SOP describes the activities and responsibilities pertaining to underground utility clearance; however, this guidance does not remove the need for professional judgment. If possible or as soon as reasonably possible deviations from this procedure while planning or executing this activity must be approved by the parties responsible for this task; i.e., project manager and/or quality Assurance Manager.

#### 2.0 SAFETY

The type of safety measures and level PPE required for underground utility clearance depends on the unique characteristics of the site and should be addressed in Work Plan(s). If the Work Plan does not address underground utility clearance, personnel at a minimum must be in PPE Level D (safety glasses, gloves, steel toed boots, and hard hat).

Additional safety measures will be addressed in the following sections.

#### 3.0 TERMS AND DEFINITIONS

- **Underground Utilities**: All utility systems located beneath grade level, including, but not limited to, gas, electrical, water, compressed air, sewage, signaling and communications, etc.
- **Ground Disturbance (GD):** Any indentation, interruption, intrusion, excavation, construction, or other activity in the earth's surface as a result of work that results in the vertical and/or horizontal penetration of the ground.

#### 4.0 ROLES AND RESPONSIBILITIES

#### 4.1 EnSafe Inc.

EnSafe Inc. is a Health, Safety, and Environmental Consulting company that is contracted by Industrial and various Governmental entities to conduct field services as part of its business model. EnSafe can advise, consult, and manage its client's projects but is not certified to clear utilities. Depending on where potential underground utilities are located, i.e., public property or private property, EnSafe can as part of the statement of work contact the various utility locators required to provide utility clearance.

#### 4.2 EnSafe Project Manager

The project manager or project designee will be administratively responsible for making sure underground utility clearance has been performed and area has been deemed safe to begin any intrusive work. If utilities are present that will affect completion of a specific intrusive task, the project manager will inform the client and assist the client in identifying alternatives that can help achieve project goals. The project manager's responsibility to certify that the Work Plan has been read by all field personnel conducting the field activities and they understand all procedures contained therein. The project manager or designee will conduct periodic audits over the course of the project to make sure the Work Plan is being followed.

If there is an unforeseen change due to a potential encounter with an underground utility the project manager will contact the client as soon as reasonably possible and document the occurrence. In a case where a potential safety hazard could develop the project manager will inform the Corporate Health and Safety Officer and if necessary contact appropriate individuals within upper management. It is the Project Manager's responsibility to inform the client of any significant changes to the Work Plan including safety protocols.

#### 4.3 EnSafe Field Manager

The Field Manager is responsible for overseeing that the underground utility SOP is implemented and that all underground utility lines are clearly marked.

If field changes occur such as an encounter with a un-mark underground utility the Field Manager will stop all work and contact Project Manager. Work will not begin until the utility has been properly marked.

If a safety issue arises and the activity is stopped because of a safety hazard, it is the field manager's responsibility to make sure all personnel are accounted for and out of the danger zone. Depending on the situation and if appropriate the following contacts need to be made:

- 1) First Responders
- 2) Utility
- 3) Corporate Health and Safety Officer
- 4) Project Manager
- 5) If 2, 3, and 4 are unavailable appropriate Branch Manager and/or principal
- 6) Client

#### 4.4 EnSafe Field Personnel

All field personnel must read and be familiar with underground utility protocols outlined in the Work Plan. All field personnel have a stop work authority if a suspected underground utility is potentially going to be hit. Work will not begin until the project manager in consultation with the field manager, and the health and safety officer determine it is safe to continue work.

#### 5.0 PROCEDURE

Ground disturbance may be conducted for a variety of purposes, including, but not limited to, exposing existing buried lines, soil sampling, remedial excavations, advancing soil borings, installing monitoring wells, or excavating test pits.

Improper ground disturbance may impact a buried pipeline or utility line and cause a major release of a hazardous substance, flood, electrocution, or high pressure gas/air/water. Serious injuries and significant property damage have resulted from insufficient/inadequate identification of underground installations during the course of ground disturbance work.

To control hazards associated with coming in contact with such installations, the American Public Works Association's (APWA) guidelines for the uniform identification of underground installations has been adopted.

#### Personal Protective Equipment

 Long or short sleeved	shirt (	season	dependent)	and	pants	(coveralls/Nomex	LILA	fo
upstream oil and gas)								

- Safety toe boots
- Hard hat
- Safety glasses
- High-visibility clothing
- Gloves
- Respirator with organic vapor/particulate filter cartridge (for use when the exposure exceeds the occupational exposure limit stated on the MSDS), as required
- Hydrogen Sulfide (H2S) Monitor (for areas with known or suspected H2S)

#### Training

- Individuals conducting underground surveys shall successfully complete a Ground Disturbance training course.
- If clients have additional training requirements in order to conduct underground surveys individuals will be required to complete these requirements.

#### Underground Utility Lines

To avoid injury from electrical and other utilities on site, utility lines shall be located and marked prior to conducting any drilling or digging on site. If available, refer to site drawings and/or client interviews for information pertaining to utilities on site.

#### Types of underground lines (not an all-inclusive list):

- Gas line
- Potable and non-potable water lines
- Sewer line
- Power line
- Cable television/communication line
- Cathodic protection lines
- Grounding cable
- Process piping/flow line
- Air line

#### 5.1 Pre-Field Work

Prior to conducting the ground disturbance, all utilities that pass within a 25-foot radius of the intrusive work are your search and control area. The following bullets require attention:

- Notify all pipeline and utility companies, and confirm that their notification requirements are fulfilled prior to conducting a ground disturbance.
- Identify pipelines, power lines, utilities, and irrigation canals in a 25-foot zone of the work area with a representative of the company/owner.
- On active and formerly active federal facilities, and any private property requiring intrusive ground activities, a properly trained (see Section 4.8) and competent third party utility locator shall be used.
- Get approval by a representative of the company/owner for work within a right-of-way (ROW)
  or within 15 feet of a line if there is no ROW.
- Prepare a site map identifying the search area, the ground disturbance area, and known underground utilities.

- Perform a site walk after all known utilities have been marked by the applicable locators.
   Confirm that these locations are not within the planned disturbance area.
- **5.1.1** Look for underground utility indicators, such as:
- Warning signs where pipelines cross roads or water courses.
- Cut lines, wells, underground tanks, or valves that may indicate the presence of pipelines.
- Ground settling from previous underground utility installations.
- If applicable talk to nearby landowners and residents.
- Vegetation appearing "different and/or depressed" from the surrounding vegetation (e.g., greener, taller, shorter, or more brown than surrounding vegetation).
- **5.1.2** When working within an underground utility right-of-way, and if required, you shall get written approval from the utility representative prior to doing your work.
- **5.1.3** Call the utility at least three full working days before you dig so the utility can be located and marked. No excavations will be performed until this is accomplished.

#### 5.2 Excavation for Utility Repairs

- All underground utilities where repairs are to be conducted shall be hand exposed or hydrovac'd within 3 feet of a mark out or within the distance required by the owner of the utility before operating any mechanized equipment.
- Make arrangements for supervision ("a Signal Person") during hand exposure.
- If for any reason these hand excavations are temporarily filled in, mark them.
- Make arrangements for supervision ("a Signal Person") during any mechanical excavation within 15 feet of the underground utility.
- Make arrangements for supervision ("a Signal Person") during backfilling of utilities.
- When exposing utilities do not damage utilities by shovels; <u>hand-picks should not be used</u>.
- All workers have the right and responsibility to refuse to carry out any work or procedures that they feel are unsafe.

- Incidents, injuries, and near misses shall be reported immediately.
- Review the site-specific emergency response plan.
- A utility checklist must be filled out (Attachment A) before any excavation activity begins and appropriately signed.

# 5.3 Drilling

- Before any drilling activities begin, the drilling contractor's crew will be required to hand auger down at least 4-feet below ground surface at each boring location even if an underground survey has cleared the location for drilling. This requirement may change based on ground and geologic conditions. Check with utility companies as to burial requirements in a particular region.
- A utility checklist will be filled out, signed, and notes and explanations will be provided. If the 4-foot test hole cannot be achieved, the project manager will be notified.

# 5.4 If an underground facility is hit, stop the work immediately:

- Clear the area if there is eminent danger to life and property; notify first responders, if required.
- Once the area is deemed safe then immediately call
  - Resolution Consultants Health and Safety Officer, if safety issues are present
  - Resolution Consultants Project and Program Managers
  - Facility's responsible party
  - Utility owner
  - An individual on the project team will be identified prior to any ground disturbance that will be responsible for contacting required agencies and regulatory bodies, if required.
- At a minimum Resolution Consultants employee will report:
  - The location of the contact and type of damage
  - Safety pre-cautions taken
  - Any first responder actions
- A photographic record of damage (if safety allows) and all subsequent immediate actions should be collected, as well as documentation in the field log book.
- The government agencies may require a written record; therefore, Resolution Consultants will conduct an incident investigation to present to the client with leasons learned and any corrective actions that may be required.
- Work will not resume until repairs have been made and the utility is properly and completely located.

#### 6.0 IDENTIFICATION OF INSTALLATIONS

Extreme caution shall always be exercised when attempting to locate underground utilities. The location of utilities can be in some cases not consistent as shown on drawings, as indicated by the placement of surface signage, or as described by personnel. Coordination and planning of the job shall be required with the client or owner.

- Prior to digging and drilling operations, the client shall always be informed of the potential location(s) of underground utility systems.
- If a utility permit is required from the client or owner, it shall be obtained before any work begins.
  - Caution: The client or owner may think they know where utilities are located or may not have knowledge; therefore, all utilities need to be independently located
- All underground installations shall be considered "live" and "operational"
- If utilities are present within 10 lateral feet of the work area, the planned ground disturbance shall be offset laterally away from the marked underground utility.

The State and/or local One Call System or its equivalent will be called out in areas they are responsible for and a reference ticket obtained. Line location documentation (or appropriate regional agency or company) provides a listing of companies that have registered buried facilities in the proposed work area. Some public utilities and private companies are not members of the One Call System. In order to give line operators sufficient time to respond to a request to locate, a minimum waiting period of 72 business hours is required prior to beginning work.

# 7.0 IDENTIFICATION OF INSTALLATIONS

Once the underground installation has been identified, proper surface markings shall be made in accordance with the guidelines contained in this SOP or as contract-specified.

Color-coded surface marks (paints or similar coatings) shall be used to indicate the type, location, and route of buried installations. Additionally, to increase visibility, color-coded vertical markers (temporary stakes or flags) shall supplement surface marks. Intrusive activities should begin immediately after utilities have been marked. If markings have faded or temporary stakes or flags are not present, the area will have to be re-surveyed.

# Uniform Color-Coding

		•			
—	Red:	Electric Power I	Lines, Cables,	Conduit,	and Lighting Cables

— Yellow: Gas, Oil, Stream, Petroleum, or Gaseous Materials

Orange: Communication, Alarm or Signal Lines, Cables, or Conduit

— Green: Sewers and Drain Lines

— White: Proposed Ground Disturbance area

— Pink: Temporary Survey Markings

— Purple: Nonpotable Water

### 8.0 RECORDS

The following records on the identification of and response to underground utilities will be maintained in the project files:

- All information regarding the identification of underground installations (this information can also be transferred to the appropriate drawings and/or prints and shall be available on site).
- Drawings and/or prints shall be maintained for the life of this project.
- Pre-drilling/excavation utility checklist
- One-call tickets

# 9.0 ATTACHMENTS

Pre-drilling/excavation utility checklist



# PRE-DRILLING/EXCAVATION UTILITY CHECKLIST (COMPLETE IN ADDITION TO THE SWAP) Site Name & Address:

site iva	me & Address:			
	Project Number & Manag			
	ed Date of Field Work & I			
		AFTER fieldwork has been completed:	ibi a a	
		planning stages (B)=To be accomplished onsite before fieldwork activ		
		BLIC AND PRIVATE PROPERTY) REQUIREMENTS	YES	NO
		or One Call" been notified to mark the locations of all underground of Fieldwork is Extended Past 2 Weeks After Inquiry.		
2(A).	One-Call Ticket Info.	Date Called: One-Call Phone#:		
(	REQUIRED BY LAW).			
		Beginning & Expiration Date/Time:		
		Entities to be contacted separately:		
2/40	D) 11 6			
		her relevant) personnel been interviewed and asked to provide copies		
		s and drawings about underground utilities near the excavation area?		
		ough been accomplished to identify surface indicators of utilities?		
		ns of underground utilities been marked on the surface by one-call		
		Id personnel understand how these utilities traverse underground?		
	-	f utilities been inserted on the work area drawing(s)?		
		mation concerning the type/location/depth of known underground		_
		esponsible supervisor or contractor at the work site for review and		
	ole offset/relocation?			
		d pipe locating devices (PM/Qualified Safety Review approval)		
	used to confirm position			
		neter" tools been used to dig trial holes (minimum depth of 4 FEET		
		minimum diameter of downhole sampling tool, including any		
		lly identify position/depth of the underground utilities, or to determine		
		within the test location? Depending on regional subsurface (Depth of		
		nditions, unground utilities may be buried deeper than 4 feet. All		
		depth shall be documented at the bottom of this page.		
EXCAVATION ONLY		ration (at all times), a watch is kept for evidence of cables, pip	es, or	otner
)L X	underground utilities no	ot previously identified.		
N A	dd(D) If have a suit		1	- l
C C		pment is required to cross an area where underground utilities are	known	to be
Ω	present, the cross poin	its are kept to a minimum and are clearly marked.		
	Please refer to the back	k of this form for explanations and tips on how to answer the question	ıs listec	abov
		this checklist for comments/concerns to any of these questions an		
		er for the specific State/Region that fieldwork is performed.	•	
	,	, , , , , , , , , , , , , , , , , , , ,		
	<b>A Qualified Safety R</b>	Reviewer MUST be consulted and approve this site-specific t	<u>form E</u>	<b>EFOR</b>
	fieldwork may comm	nence if the answer to ANY Question on the checklist is NO.	This a	approv
		erson) may be obtained/received immediately prior to starting work of		
	advanced noticed is pre	eferred to allow the reviewer time to look at maps/drawings of the sit	e and a	all othe
	relevant documents.			
<u>Checkl</u>	ist Submitted By:	Qualified Safety Review (I	f Need	<u>led):</u>
Name:_		Name:		
Signatu	re:	Signature:		
Jigi iatu		Signatule:		
Date:		Date:		



# PRE-DRILLING/EXCAVATION UTILITY CHECKLIST (EXPLANATIONS AND TIPS)

The instructions below have been developed to assist field personnel in accomplishing the tasks on the front of this form. If at any time field personnel are unclear on how to perform these necessary pre-job steps, refer to the Qualified Safety Reviewer list on the EnSafe Intranet.

(A)=To be accomplished during planning stages (B)=To be accomplished onsite before fieldwork activities

### **UNDERGROUND UTILITIES (PUBLIC AND PRIVATE PROPERTY)**

**1(A).** This is REQUIRED no matter if the work area is on public or private property. Borings/excavations should be located onsite before One-Call notification, if possible, with WHITE paint/flagging. **Update One-Call every 2 weeks, and locators need 3 working days to mark all utilities within the work area.** 

**2(A).** This may be accomplished by telephone/internet. Most state-specific one-call agencies are open 8AM-5PM local time, Monday thru Friday.

**3(A&B).** This may happen the morning of the drilling/excavation activities to be performed. All personnel need to be aware of underground utilities within (or near) the work area. Offsets may be performed to minimize the probability of encountering underground utilities.

**4(B).** Example: light posts, valve pits, pit covers, curb/gutter inlets, manholes, surface indentations, saw cut areas, etc. This is best performed during the pre-bid site visit, but may be performed immediately before activities.

**5(B).** One-Call color markings typically are as follows: WHITE (Excavation/Borings), RED (Power/Electrical), YELLOW (Gas/Petroleum), ORANGE (Communication/Fiber Optics), BLUE (Potable Water), GREEN (Sanitary/Storm Sewer). Review all colors and positions with field personnel prior to beginning drilling/excavating.

**6(A&B).** This refers to simply looking at the underground utilities onsite and plotting them (by hand initially) on the site drawing or aerial.

**7(B).** If NO, please explain. After all underground utilities have been plotted on the drawing, review the locations with the EnSafe PM, all personnel (including subcontractors), and the client if deemed necessary. This will help to orient all field personnel as to the location of the underground utilities within or near work operations. If the utilities are marked within a 3 horizontal feet lateral distance of the boring/excavation, offsets SHOULD be considered.

**8(B).** This refers to the use of a private utility locator to assist in locating underground utilities on private property that haven't been located by the One-Call system. This is highly dependent upon the makeup of the underground utility (metal, plastic, clay terra cotta, etc.) and complications due to rebar within concrete, multiple utilities crossing points, etc. Only previously trained personnel (most likely private utility locator and/or geophysical subcontractors) should use these devices. The Qualified Safety Reviewer AND the EnSafe PM AND the client will make the decision TOGETHER if a private utility locator is required.

**9(B).** Example — hand augers, probe rod, vacuum extraction, post-hoe digger, etc. This is NON-NEGOTIABLE for drilling activities. Every boring must be advanced (without mechanical means) to a depth of four (4) feet below ground surface (or maximum boring depth if boring terminal depth is less than 4 feet). Only exception is where large boulder or bedrock in within the top 4 feet of the boring. Boring may be halted at a depth less than 4 feet if it is confirmed and documented that the boring is blocked by rock with apparent diameter greater than that of the boring/trial hole.

EXCAVATION ONLY

**10(B).** This is site-specific, but usually no closer than 3 horizontal feet from any and all underground utilities (especially lines with high pressure or voltage/flammable/combustible substances). The safe distance for overhead utilities is 10 horizontal - 10 vertical feet (up to 50kV). Stay alert at all times. All personnel (EnSafe and Subcontractors) have stop work authority in reference to underground utilities. No job is too important to compromise safety.

**11(B).** The depth/alignment of the underground utility to be crossed should be determined to prevent damage to each buried utility.

#### Insert Field Notes/Concerns Here:



# **Subsurface Utility Location Team Members**

Memphis, TN – Wesley Goodnight, Dave Fuehrer, Joe Matthews, Jason Broughton,

Ben Brantley

Nashville, TN – Tammy Williams, Greg Olin, Troy Estes

Knoxville, TN – Brian Caldwell

Charleston, SC – David Warren

Bowling Green, KY – David Doyle, Ric Federico

Cincinnati, OH – Jim Rathbone

Cleveland, OH – Ned Baker, Wendy Zayac

Dallas, TX – Tom Wiberg, Jay Spence

Hartford, CT - Rob McCarthy

Londonderry, NH - Robert Francis

Jackson, MS – Brian Derry

Pleasant Hill, CA – Jim Madden

Jacksonville, FL – Frank McInturff

Additional Corporate Resources – Paul Stoddard, Jay Spence, Jeff James, David Farrell

# Standard Operating Procedure Drilling, Boring, and Direct Push Probing

These standards will ensure continuity within the organization.

#### **Preamble**

This standard operating procedure (SOP) is designed to provide the user with minimum requirements to be followed when drilling and boring work are performed. The SOP should be part of a project's sampling and analysis plans.

Before using this SOP, and as part of the due diligence, the user is required to check if local, state, and federal rules/guidance apply to drilling and boring work. If a difference exists between local, state, and federal SOPs and those contained herein, the local, state, and federal SOPs takes precedent. If this SOP is modified per agreement between parties associated with the activity, the agreed changes will become part of the SOP and the modifications will be appended to this SOP for the record.

#### 1.0 PURPOSE AND SCOPE

The purpose of this SOP is to provide the user(s) guidance on requirements when conducting drilling and boring work.

This SOP describes the activities and responsibilities pertaining to these activities; however, this guidance does not remove the need for professional judgment. If possible and as soon as reasonably possible deviations from this procedure made while planning or executing this activity must be approved by the parties responsible for this task; i.e., Project Manager and/or Quality Assurance Manager.

# 2.0 SAFETY

The type of safety measures and level of personal protective equipment (PPE) required for drilling is project/site-specific and will be addressed in Work and Health and Safety Plan(s). All EnSafe and vendor personnel engaged in drilling-related activities must follow the PPE requirements listed in the Work and Health and Safety Plan(s). At a minimum, personnel must don Level D PPE, including safety glasses, gloves, steel-toed boots, and hard hat; hearing protection is recommended; however, it is important to be able to understand verbal commands at all times.

Additional safety measures will be addressed in the following sections.

#### 3.0 TERMS AND DEFINITIONS

None

#### 4.0 ROLES AND RESPONSIBILITIES

### 4.1 EnSafe Inc.

EnSafe Inc. is a Health, Safety, and Environmental Consulting company that is contracted by Industrial and various Governmental entities to conduct field services as part of its business model. EnSafe can advise, consult, and manage its clients' projects but is not a certified or licensed drilling contractor. EnSafe can bring under contract and oversee licensed vendors that can provide drilling services required for a specific task.

# 4.2 EnSafe Project Manager

The Project Manager or project designee will be administratively and technically responsible for making sure drilling activities follow the Work Plan and all outlined health and safety measures. If unknown situations arise that affects drilling operations, the Project Manager will inform the client and assist the client in identifying alternatives that can help achieve project goals. It is the Project Manager's responsibility to certify that the Work Plan has been read by all field personnel conducting the field activities and that they understand all procedures contained therein. The Project Manager or designee will conduct periodic audits over the course of the project to make sure the Work Plan is being followed.

In a case where a potential safety hazard could develop the Project Manager will inform the Corporate Health and Safety Officer and if necessary contact appropriate individuals within upper management. It is the Project Manager's responsibility to inform the client of any significant changes to the Work Plan including safety protocols.

# 4.3 EnSafe Field Manager

The Field Manager is responsible for overseeing that the site-specific drilling SOP is implemented. As noted in Section 4.5, below, the drilling contractor's designated employee is responsible for the proper implementation of the SOPs related to the operation of drilling equipment. As an additional responsibility the Field Manager will act as the site's Health and Safety Officer if one is not assigned to be in the field as the activity is taking place.

If field changes occur the Field Manager will contact Project Manager and document the changes in the field logbook.

If a safety issue arises and the activity is stopped because of a safety hazard, the Field Manager's responsibility is to make sure all personnel are accounted for and have moved out of the area of potential risk. Depending on the situation, and if appropriate the following contacts will then need to be made:

- 1. First Responders
- 2. Utility (if struck)
- Corporate Health and Safety Officer
- 4. Project Manager
- 5. If 2, 3, and 4 are unavailable appropriate Branch Manager and/or principal
- 6. Client

#### 4.4 EnSafe Field Personnel

All field personnel must read and be familiar with this SOP and drilling protocols outlined in the Work Plan. All field personnel have a "Stop Work Authority" if a suspected safety issue should arise. Work will not begin until the Project Manager in consultation with the Field Manager and the health and safety officer determine it is safe to continue work. EnSafe personnel are not part of the drilling crew and will not under any circumstances directly operate any of the drilling or probing equipment owned

by the drill contractor. The only exception is to engage the "kill switch" of the drilling if a health and safety issue develops and immediate action is necessary.

# 4.5 **Drilling Contractors**

Drilling contractors have direct control over the application and operation of all drilling, boring, and probing equipment owned by their organization. It is the drilling contractor's operator's responsibility to implement safe work practices and SOPs provided by the drilling contractor's project management or supervisory staff supplemented by good judgment, safe control, and caution whenever operating drilling, boring, and probing equipment.

It is the drilling contractor's designate onsite individual that is the responsible person for safety for the drill crew. The contractor's safety person's responsibilities include, but are not limited to:

- Consider the "responsibility" for safety and the "authority" to enforce safety to be a matter of first importance.
- Be the leader in using proper PPE and set an example following all PPE requirements.
- Enforce the use of proper safety equipment and take appropriate corrective action when proper PPE is not being used.
- Understand that the proper maintenance of tools and equipment and general housekeeping on the drill rig will provide an environment that promotes and enforces safety. See Sections 4.6 for housekeeping and maintenance requirements of this SOP.
- Ensure that the drilling operator has had adequate training and is thoroughly familiar with the rig, its controls, and its capabilities prior to commencement of drilling activities.
- Inspect the rig at least daily for any equipment deficiencies ensuring they are repaired, immediately (a suggested list of items to be inspected, but not all encompassing, can be provided, if requested).
- Check and test all safety devices
- Ensure that all new rig workers are informed of safe operating practices on and around the rig.
   The safety person should ensure that each new employee reads and understands the safety procedures.
- Ensure that a first aid kit and fire extinguishers are available and properly maintained on each rig and on each additional vehicle, and that all field crew be trained in their uses.
- Maintain a list of addresses and telephone numbers of emergency assistance units (ambulance services, police, hospitals, etc.), and inform other members of the drill crew of its location.

- Observe the mental, emotional, and physical capability of workers to perform the assigned work in a proper and safe manner.
- Rig Crew and Other Field Personnel employed by the drilling contractor (Those employees involved in fieldwork): All personnel engaged in site activities are required to become thoroughly familiar with, and to conform to, the provisions of EnSafe' safety plan, procedures, and such other safety directives as may be considered appropriate by Project Managers, Safety Officers, and Supervisors.
- Rig Workers: Personnel are encouraged to offer ideas, suggestions, or recommendations regarding any operational condition, procedure, or practice that may enhance the safety of site personnel or the public. Their primary responsibilities will be:
  - Perform all required work safely.
  - Familiarize themselves with and understand the Work and Health and Safety Plan(s), including proper use of personal protective equipment.
  - Report any unsafe conditions to supervisory personnel.
  - Be aware of signs and symptoms of thermal stress.
  - Have "Stop Work Authority" if unsafe conditions arise during drilling operations.

# 5.0 TRAINING

All drilling operators and assistants shall have industry-standard safety training and be versed in the equipment to be utilized. This may include, but is not limited to, HAZWOPER, Petroleum Safety Training (or Construction Safety Training), and others as appropriate.

#### 6.0 PERSONAL PROTECTIVE EQUIPMENT

For most groundwater and soil drilling projects, PPE is dependent on hazard exposures and are outlined in the Statement of Work issued by EnSafe. At a minimum:

- Hard hat: Hard hats shall be worn by everyone working at a drilling/boring site. Hats should meet the requirements of ANSI Z89 and be kept clean and in good repair with the headband and crown straps properly adjusted for the employee.
- Safety shoes: Safety shoes or boots shall be worn by all drilling personnel and all visitors to the site who observe operations within close proximity of the rig. Safety shoes or boots should meet the requirements of ANSI Z41.1.
- Safety glasses: All rig personnel shall wear safety glasses meeting the requirements of ANSI Z87.1.

- High Visibility Class II Safety Vest shall be worn by all EnSafe employees. All rig personnel
  should attempt to wear high-visibility clothing that should be close fitting and not have large
  cuffs or loose material that can catch on rotating or translating components of the rig.
- Hearing protection is optional but all rig personnel must be able to hear any safety warnings.
- Close fitting gloves and clothing: All rig personnel should wear gloves for hand protection
  against cuts and abrasions that could occur while handling wire rope or cable and from contact
  with sharp edges and burrs on drill rods and other drilling or sampling tools. Gloves should be
  close fitting and not have large cuffs or loose ties which can catch on rotating or translating
  components of the rig. If there is potential exposure to hazardous environmental media, then
  inner protective gloves maybe warranted.
- Other protective equipment: For some operations, the project may dictate use of other
  protective equipment. The management of the contractor and its safety person shall determine
  the requirements; EnSafe will be informed of any changes to safety protocol and will note the
  changes in the field log book.
- When drilling, boring, or probing is performed in chemically or radiological contaminated ground, special protective equipment and clothing will probably be required.
- The clothing of the individual rig worker is not generally considered protective equipment; however, clothing should be close fitting and comfortable without loose ends, straps, draw strings or belts or otherwise unfastened parts that might catch on some rotating or translating component of the rig. Rings and jewelry should not be worn during a work shift.

#### 7.0 HOUSEKEEPING

A key requirement for safe field operations is that the drilling contractor safety person and drill rig crew understands and fulfils the responsibility for maintenance and "housekeeping" on and around the drill rig, including the following:

- Suitable storage locations should be provided for all tools, materials, and supplies so that tools, materials, and supplies can be conveniently and safely handled without hitting or falling on a member of the crew or a visitor.
- Storage or transporting tools, materials, or supplies within or on the mast (derrick) of the rig should be avoided.
- Pipe, drill rods, probe rods, casing augers, and similar tooling should be orderly stacked on racks or sills to prevent spreading, rolling, or sliding.
- Penetration or other driving hammers should be placed at a safe location on the ground or be secured to prevent movement when not in use.

- Work areas, platforms, walkways, scaffolding, and other accesses should be kept free of materials, debris, obstructions, and substances such as ice, grease, or oil that could cause a surface to become slick or otherwise hazardous.
- All controls, control linkages, warning and operation lights, and lenses should be kept free of oil, grease, and/or ice.
- Do not store gasoline in any portable container other than a non-sparking, red safety container with a flame arrester in the fill spout and having the word "gasoline" easily visible.
- Any release of hydraulic fluids and/or fuels must be contained. If a spill occurs it is the drilling contractor's responsibility to collect the product and decontaminate solid surfaces. If the spill occurs in unsolid surfaces, such as soil, sand, etc., the affected media will be dug up, containerized, and properly labeled. It is the subcontractor's responsibility to dispose of the containerized material. A record of the release must be noted, the project manager notified, and recorded steps taken for corrective action.

EnSafe staff must also understand and fulfill the responsibility for maintenance and "housekeeping" for their activities performed around the drill rig. Should the Work Plan include activities such as soil screening, soil or groundwater sample collection, soil logging, or other activities which prompt the EnSafe field staff to set up a work station in the vicinity of the drilling rig; the work station will be set up a minimum distance from the drilling rig equal to the length of the fully extended drilling rig mast (derrick). Any deviation from this, for example due to Site-specific traffic flow, work area constraints, or the like, must be approved by the EnSafe Field Manager or onsite Health and Safety Officer (if applicable) prior to the commencement of work. Staff utilizing the work station will orient themselves to face the drill rig, and will not work with their backs to the rig for any extended period of time.

#### 8.0 TRAFFIC CONTROL

When operating near public vehicular and pedestrian traffic, the onsite personnel shall take every precaution necessary to see that the work zone is properly established, identified, and isolated from both moving traffic and passer-by pedestrians.

All traffic control devices shall be installed, placed, and maintained in accordance with the Traffic Control Plan, client specifications, and/or the Manual of Uniform Traffic Control Devices (MUTCD). Traffic control devices shall consist of and not be limited to:

- Directional and informational signage
- High visibility barricades, cones, or barrels
- Lighting
- Other equipment and devices as required

#### 9.0 MAINTENANCE & INSPECTION

Good maintenance and thorough inspection will make operations safer. Maintenance tasks should be done safely by a qualified maintenance person. Inspection and maintenance tasks include but are not limited to the following requirements:

- Inspections shall be completed at the beginning of each day by the drilling operator and in the
  presence of an EnSafe employee. (A suggested list of items to be inspected, but not all
  encompassing, can be provided, if requested).
- PPE appropriate for site conditions (see Section 2.0) should be worn when performing maintenance on a rig or on drilling or probing tools.
- Drill rig repairs are the responsibility of the drilling contractor and all safety procedures outlined in the Contractor's Health and Safety plan during these activities will be supervised by the Contractor's Health and Safety representative.

#### 10.0 HAND TOOLS

A large number of hand tools can be used on or around a drill or probe rig. The drilling contractor will ensure that hand tools are in good working order and their crews are knowledgeable about their uses.

#### 11.0 CLEARING WORK AREAS

Prior to set up, adequate site clearing and levelling should be performed to accommodate the rig and supplies and provide a safe working area. Clearing the site includes clearing the intended drilling area of underground utilities in accordance with EnSafe's SOP for clearing Underground Utilities (https://team.ensafepoint.com/gfs/EnSafe%20Field%20Forms/Forms/AllItems.aspx). Drilling or probing should not be commenced when tree limbs, unstable ground, or site obstructions cause unsafe drilling or tool handling conditions.

#### 12.0 DRILLING AND PROBING OPERATIONS

Drilling and probing operations will be conducted for the task outlined in the Statement of Work. The physical act of drilling and probing is the responsibility of the drilling contractor; but it must be done in a safe yet efficient manner. **EnSafe employee is not part of the drilling crew and will not participate in the drilling activity**. The following safety measures shall be taken during drilling and probing operations onsite:

- Operations will be terminated during an electrical storm, and all crew members will move away
  from the rig. If lightning is observed, shut down all rig operations immediately. A minimum of
  30 minutes without observed lightning or thunder must pass before drilling is resumed.
- All site personnel are responsible for the health and safety of field operations, and includes Stop Work Authority" if unsafe conditions arise during drilling operations.

• EnSafe employees will be viligant in the identification of any changes in field conditions that may warrant stopping the activity and clearing personnel a safe distance from the drill rig. Once personnel are at a safe distance from the drill site, EnSafe employee will immediately inform the drilling contractor's onsite supervisor, EnSafe health and safety officer, and Project Manager of the issues. Drilling will not resume until the "All Clear" is obtained from EnSafe' health and safety officer.

### 13.0 SITE MOVEMENT OF EQUIPMENT

The drilling contractor is responsible for moving drill rig and associated equipment from one location to another. If driving on public roads the driver must obey all vehicle laws.

#### 14.0 FIRST AID

- At least one member of the drilling crew (and if only one, preferably the drilling and safety supervisor) should be trained to perform first aid. Up to date first aid and CPR certifications will be required.
- EnSafe employee must also be trained in first aid and CPR and have current certification.
- A first aid kit will be available and well maintained on each drill site and in each vehicle.

#### 15.0 RIG ALTERATIONS

If EnSafe's employee determines that alterations to a rig or drilling or probing tools have been done outside manufactures specification, that piece of equipment will not be used in the course of drilling operations.

#### 16.0 RECORDS

None

# 17.0 ATTACHMENTS

- EnSafe' Inspection Check List
- Utility Checklist

# Standard Operating Procedure Guidelines – Completing Soil Boring Logs These standards will ensure continuity within the organization.

#### **Preamble**

This standard operating procedure (SOP) is designed to provide the user with guidance that will ensure continuity in recording field subsurface observations onto a soil boring form between EnSafe observers and projects. The soil boring form to be used should be part of a project's sampling and analysis plans. This SOP should be attached to all projects that include a drilling program.

Before using this SOP, and as part of the due diligence, the user is required to check if local, state, and federal rules/guidance apply to subsurface descriptions and/or how they are recorded on soil sampling form. If a difference exists between the SOP herein and the state and federal SOPs, the local, state and federal SOPs take precedence. If this SOP is modified per agreement between parties (clients, EnSafe, and/or regulators) associated with the activity, the agreed changes will become part of the SOP and the modifications will be appended to this SOP for the record.

Detailed information concerning Soil Boring Log guidelines can be currently found on the EnSafe's Intranet at https://team.ensafepoint.com/gfs/EnSafe%20Field%20Forms/Forms/AllItems.aspx.

### 1.0 PURPOSE AND SCOPE

Continuity of observations between field personnel and/or projects during subsurface activities is important to good scientific practice and data analyses. Poor observation and recording may lead to erroneous conclusions that could result in cost and regulatory consequences. Thus, the purpose of this SOP is to provide the field individual with the tools to organize a sequential thought process when describing soil and rock during drilling activities.

This SOP describes the guidance to be used; however, this does not remove the need for professional judgment. If possible or as soon as reasonably possible, deviations from this guidance while planning or executing this guidance must be approved by the parties responsible for this task; i.e., Project Manager.

# 2.0 SAFETY

The type of safety measures and level of personal protective equipment (PPE) during the recording of field observations is important. PPE outlined in the Sampling and Analysis Plan (SAP) must be worn in the work zone. If a SAP has not been created for the activity then EnSafe's Work and Health and Safety Plan will be followed.

Drilling activity is the main hazard area that must be avoid when describing field samples. Therefore, as with field sampling, a safe distance must be maintained from the drill rig. This distance is greater than the height of the drill rig when the dreck is up.

Wear proper PPE as outlined in the SAP to avoid in coming in contact with subsurface media such as vapor, water, soil, or rock.

Make sure you are facing the drill rig when describing samples to:

- Maintain visual contact with the drill crew; and,
- Quickly react if a health and safety issue arises.

Make sure the drill rig is located in a position downwind or your location.

All individuals associated with the activity have a **Stop Work Authority** if a health and safety hazard presents itself. Work will not resume until the site's health and safety has been resolved.

# 3.0 TERMS AND DEFINITIONS

None

#### 4.0 ROLES AND RESPONSIBILITIES

# 4.1 EnSafe Project Manager

The project manager or project designee will be administratively and technically responsible for making sure the soil sample field form is filled out properly. The project manager's responsibility is to ensure that the Work Plan has been read by all qualified field personnel conducting the field activities and that they understand all procedures and guidance contained therein. Moreover, the project manager's is responsible for ensuring the project is properly staffed by qualified team members that can describe subsurface media. Some states and some agencies within certain states require the field staff member who describes lithology during drilling activities to hold certain certifications, typically a Registered or Professional Geologist or Engineer. The project manager or designee will review all field soil forms for quality control and to make sure they are filled out properly. This review should be completed at the end of each field day, so if corrective actions need to be made, they are taken before the start of the next field day.

Before reports, documents, or letters are released to the project team (clients, regulators, etc.) the final field forms, be they hand written or produced in a well log computer program, must go through the standard EnSafe quality assurance/quality control (QA/QC) process. If required by state regulations, these forms must be stamped by an appropriately-licensed Geologist or Engineer in the state where the activity took place. It is the role of the Project Manager to follow these procedures.

#### 4.2 EnSafe Field Manager

As with the Project Manager, the Field Manager is responsible for making sure the field forms are completed per this SOP on a daily basis as this will ensure that if corrective actions are necessary they have been instituted as instructed. If so designated by the Project Manager, the Field Manager will review all field soil forms for quality control purposes and to make sure they are filled out properly. This review should be completed at the end of each field day, so if corrective actions need to be made, they are taken before the start of the next field day.

# 4.3 EnSafe Field Personnel

All qualified field personnel must read and be familiar with this SOP. Field personnel not familiar with describing subsurface media should inform the Project Manager and/or Field Manager that they do not have the qualifications to conduct this activity.

#### 5.0 TRAINING

Only field personnel qualified to describe subsurface media should fill out soil boring logs.

#### 6.0 EQUIPMENT AND SUPPLIES

EnSafe boring log field forms can be found online at <a href="https://team.ensafepoint.com/gfs/EnSafe%20Field%20Forms/Forms/AllItems.aspx">https://team.ensafepoint.com/gfs/EnSafe%20Field%20Forms/Forms/AllItems.aspx</a> under the Form Section. The EnSafe field supply office (Les Arnold X4302) has additional hard copies of the forms.

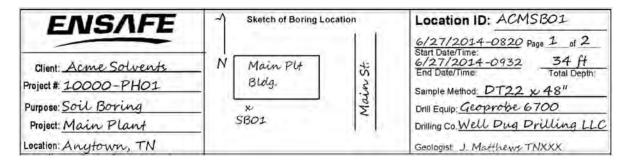
Only indelible ink pens are to be used only when filling out soil boring logs. Sharpies and pencils are not appropriate for this activity.

#### 7.0 PROCEDURE(S)

The following procedure(s) along with guidance on producing well logs in LogPlot can be found at https://team.ensafepoint.com/gfs/EnSafe%20Field%20Forms/Forms/AllItems.aspx.

Below are guidelines for completing the soil boring form:

- Industry and company standards require use of the ASTM International D2488-06 Visual Manual Method for soil classification. The ASTM standard incorporates the Unified Soil Classification System (USCS) classification system and describes field methodologies for determining the appropriate classification of soil samples based on manual field tests.
- The soil boring log form comprises a header, body, and end notes. Specifics of each part are described below.



#### Header

The header includes an area for project information, a sketch of the boring location, location identification (ID), and equipment information.

**Project Information** — The left header box is for general project information.

**Sketch of Boring Location** — Center header box is available for a simple sketch of the boring location relative to site features and other soil borings. If known a north arrow should be on put on the sketch for orientation purposes, plus any reference distances from known cultural features.

**Location and Equipment Information** — The right header box is for entering the location ID (soil boring number), drilling start and end date and time, number of pages, total boring depth, drilling information, and geologist, or field scientist.

**Sampling Methods** — Define the type of sampler used for retrieving the soil samples. Samplers include devices associated with different drilling methods (identified under "Drilling Equip" on the header. Below is a table with basic information for sampler devices typically available.

Drilling Equip/Method	Common Make	Sample Method Abbreviation (Entry On Log)	Sample Method Description
Direct Push (DP)	Geoprobe (Gp)	DT22 x (Length as -in or -ft)	Dual tube 2.25-inch diameter
		DT325 x (Length as -in or -ft)	Dual tube 3.25-inch diameter
		DT45 x (Length as -in or -ft)	Dual tube 4.5-inch diameter
		M5 x (Length as -in or -ft)	Macro Core 2.25-inch diameter
		M7 x (Length as -in or -ft)	Macro Core 3.0-inch diameter
Hollow-Stem Auger (HSA)	Central Mining Equipment (CME)	SS x (Length as -in or -ft, dia. as -in) CS x (Length as -in or -ft, dia. as -in)	Split-spoon (or split-barrel) is a carbon steel sampler, typically 18 or 24 inches long and 2
Solid-Stem Auger (SSA)	Mobile (CIAL)	(CS with HSA method only)	or 3 inches in diameter
	Various		Continuous Sampler (CS) is typical carbon
			steel 60 inches long and 3-inch diameter.
Fluid Rotary (FR)	CME	SS x (Length as -in or -ft, dia. as -in)	SS (see above for details)
includes mud and air	Various		
Sonic	Geoprobe	Sonic x (Length -in or -ft, dia. as -in)	Steel typically 5 or 10 feet long with varying
	TerraSonic		diameter (3, 4, 6 inches)
	Various		
Hand Auger (HA)	Various	HA x (Length as -in or -ft, dia. as -in)	Auger Bucket Stainless Steel
Slide Hammer	Various	SH x (Length as -in or -ft, dia. as -in)	Sample Tube Stainless Steel or Acetate

#### Log Body

The body of the log form includes data columns to the left and lithologic descriptions to the right.

Number	Interval	Recovered Inches Driven	Miscellaneous (Time/Blow Ct)	OVA Reading (ppm)	nscs	ОЕРТН (FT)	Lithologic Description  Visual-Manual Description (ASTM D 2488-06)  (e.g.: Grain size, color, structure and other properties, moisture, odor, staining)
1	4	42/ 48	0822	0.0	Asph CL		(0 - 4 ft) Asphalt with grl base (0 - 0.5 ft); Silty Clay, brn, firm, low plst, slgt moist.
/	/	4		0.0		2=	
	/	-		0.0		3=	
2	8	44/48	0825			*	(4 - 8 ft) Silty Clay, brn grd gry, firm, low plst, slgt moist:

#### Left Section:

The left section of the form body is the area where information is recorded regarding sample run, recovery, miscellaneous information, organic vapor analyzer (OVA) readings (typically parts per million [ppm]), USCS classification group code, and depth graph.

- Sample (number and interval): Sample run is typically used to denote each sample run as a sequential serial count (upper number) and the run end or bottom depth (lower number) as feet below ground surface (bgs). This information is very useful for keeping track of the boring depth during drilling and verifying with the driller regarding the bottom depth of each run (this will vary based on drilling method, sampling equipment, drillers, and specific site conditions).
- Recovery: Enter inches of sample recovered (upper number) and inches driven (lower number) for each sample run.
- Miscellaneous: This column may be used to record a variety of information. A suggested use for this column is to enter the time the sampler is retrieved from the borehole; this would be the best sample time used for laboratory samples as it represents the initial time the sample was exposed to the atmosphere. It is also used to record blow counts, which may help to provide an indication of the density of the soil, or act as a standard penetration test.
- Organic Vapor Analyzer (OVA) Reading (ppm): Enter the field screening and/or sample head space measurement from the OVA meter. You may enter the OVA type (e.g., photoionization detector [PID], flame-ionization detector [FID], etc.) in the notes at the bottom or in the space in the header above "(ppm)."
- **USCS**: This column is for entering the soil media classification per the USCS. The ASTM D 2488-06 standard provides detailed information regarding field visual-manual methods for determining the proper USCS classification.
- **Depth (FT):** This column is a scaled graph for recording information at specific depth intervals. Space is available to the left to enter information such as water levels. The space along the depth scale should be used to enter the graphic sketch of lithologic types and analytical sampling intervals.

# **Lithologic Description:**

This is the main section of the field soil boring log form and should be used to describe the lithologic sample per the ASTM D 2488-06 standard. It details the USCS group classifications and provides the visual-manual field tests and methodology for determining the USCS groups. For consistency the following order should be followed when entering the narrative description of the lithology:

- 1) Grain size
- 2) Color

- 3) Structure and other properties
- 4) Moisture
- 5) Odor, staining, product or other observed evidence of contaminants

Other notes may also be entered in the lithologic description section of the log form, including soil samples collected for laboratory analysis (including Shelby tubes for geotechnical data) and organic and inorganic samples for contaminant assessments.

#### **End Notes**

The end notes include space to enter general notes, basic well construction information, and laboratory sampling information for up to five samples. The end notes are intended as a supplement to other documents and do not replace the necessity of entering information into the field logbook, the sampling chain-of-custody form, or, as required a well construction completion form. The best recommended use for the end notes is to record the listed information for easy reference and to facilitate completion of the report soil boring log in LogPlot, if required. This also facilitates recording this information for smaller projects such as a Phase II ESA.

Notes:	Well Co	Well Constuction		Base	Sample ID	Time	Interval	Analyses
Abd by pres grout w/tremie	Material:	Casing:			1) ACMSSB0112	0829	10.5-12ft	V, S, R8Met
Cuttings placed in Drum	Diameter:	Screen:			2) ACMSSB0130	0911	28-30ft	V, S, R8Met
#001.	Wellhead:	Grount:			3) ACMCSB0130	0911	28-30ft	V, S, R8Met
	Ballards:	Bent/Seal:			4)			
	Pad:	Sand Pack:			5)			

#### 8.0 DATA/RECORDS MANAGEMENT

At the completion of a field effort, all field forms from shall be submitted to the project manager to be maintained as a part of the project file. The field forms have been designed to provide the information to populate LogPlot computer program when required.

#### 9.0 QUALITY CONTROL AND QUALITY ASSURANCE

Field log forms are required to go through QA/QC procedures. It is the responsibility of the author of the forms to have them reviewed by the project manager and/or field manager at the end of the work day or immediately upon project completion. If an error has occurred, either in the field or during the review process, the form can be corrected by putting a single line through the error and initialing it; then placing the correct data on the form. These forms may be used in litigations or negotiations; therefore, they need to go through this QA/QC process.

#### 10.0 NONCONFORMANCE AND CORRECTIVE ACTION

Any deviations from the standard protocol, deviations from procedures specified in the SOP, or any problems that occur during procedure implementation must be documented in the field logbook or the boring log forms, and corrective action should be applied, if warranted. Alternatives to the procedures specified in the SAP may be acceptable if they conform to established field guidance protocols. If used, alternative procedures must be approved by the project manager and be properly documented in the field logbook and/or on forms.



# Standard Operating Procedure FS-02 Soil Sampling

These standards will ensure continuity within the organization.

#### **Preamble**

This Standard Operating Procedure (SOP) represents EnSafe's minimum standard of practice. State and federal requirements may vary, as may project-specific work plans, all of which must be consulted before work begins. This SOP may be modified to meet regulatory-, client-, or project-specific criteria.

#### 1.0 SCOPE AND APPLICABILITY

The objective of this SOP is to describe the approach, materials, and equipment to be used for sampling soil and collecting soil samples for analysis. The procedures in this document are to be used by field personnel when collecting and handling soil samples for physical, chemical, and toxicological analysis. This procedure applies to all EnSafe employees who participate in soil sampling efforts.

On the occasion that field personnel determine that any of the procedures described are either inappropriate, inadequate, or impractical and that another procedure must be used to obtain a soil sample, the variant procedure will be documented in field logs, along with a description of the circumstances requiring its use. If used, alternative procedures must be approved by the project manager and be properly documented in the field logs.

The sampler must be aware of special equipment and precautions necessary when sampling groundwater for per- and polyfluoroalkyl substances (PFAS). SOP FS-12 **must** be used in conjunction with this SOP when sampling for PFAS and materials (e.g., Teflon) cited in this SOP (FS-02) **must** be substituted as directed in SOP FS-12.

#### 1.1 Definitions

*Chain-of-Custody* — A process used to maintain and document the chronological and custody history of a sample.

*PFAS* — A family of complex synthetic chemicals containing fluorine and carbon atoms, which make them extremely persistent in the environment. PFAS were developed to make various products such as non-stick cookware, stain and water repellants, cleaning products, food packaging, paints, and firefighting foam.

*Shall* or *must* — When these words are associated with a procedure or other item, the item is mandatory, and performance is expected in all cases. Deviations from the SOP containing these words shall be documented.

*Should* or *may* — When these words are used, the referenced item is recommended or suggested, but not mandatory.

Standard Operating Procedure — A document that gives a step-by-step description of how a specific operation, method, or procedure is performed.



*Volatile Organic Compound (VOC)* — Any organic compound that evaporates readily to the atmosphere.

# 1.2 Related Standard Operating Procedures

The following are related EnSafe SOPs:

- AD-02 Sample Labelling and Chain-of-Custody
- FC-01 Decontamination of Field Equipment
- FD-01 Field Documentation
- FS-12 Per- and Polyfluoroalkyl Substances Field Sampling Protocol
- FT-01 General Field Testing
- FM-01 Packaging and Shipping Procedures
- FQ-01 Quality Assurance/Quality Control Sampling

# 1.3 Health and Safety

Health and safety considerations will vary according to the individual sites. Before commencing any soil sampling effort, field personnel shall review the health and safety requirements, any site-specific Health and Safety Plans, Job Safety Analysis, etc., to become familiar with the site hazards and safety requirements. Field personnel should make note of any known or potential hazards at the site, address chemicals that pose specific toxicity or safety concerns, and follow the relevant safety requirements. Field personnel shall bring to the site any personal protective equipment appropriate for the hazards expected to be encountered during field work activities. Every effort should be taken to minimize dermal contact with the soil to be sampled.

#### 1.4 Cautions

The environments in which soils are found can often contain treacherous, slippery surfaces, which afford poor footing. This can lead to slip, trip, and fall hazards. Consequently, extreme care should be taken when accessing sampling locations, particularly when working in areas with brush or sites with industrial debris. The sampling team shall consist of at least two people, particularly when the sampling involves sampling at remote or isolated sites.

Sufficient representative sample volume should be determined and collected for proper collection of analytical soil samples.

#### 1.5 Interferences

Sampling methods and procedures shall not interfere with soil sample quality. The exact methods for sampling should be selected carefully depending on the depth and type of soil.

Any time a vertical or near vertical soil surface is sampled, such as when using shovels or similar devices for subsurface sampling, the surface should be dressed (scraped) to remove smeared soil or foreign debris. This is necessary to minimize the effects of contaminant migration interferences due to smearing of material from other levels or at the surface from other sources.



#### 1.6 Personnel Qualifications

Personnel conducting soil sampling must be knowledgeable of the procedures in this SOP and other related EnSafe SOPs. Training for each procedure will be dependent on the specific procedure. Field personnel are responsible for conducting soil sampling procedures according to this SOP and the site-specific planning documents.

#### 2.0 APPARATUS AND MATERIALS

Field personnel shall consult site-specific planning documents to determine the equipment requirements for the sampling procedures to be followed during the sampling effort. The specific apparatus and materials required will depend on the soil samples being collected.

The following equipment and materials may be needed to conduct the sampling procedures outlined in this SOP:

- Aluminum foil
- Polyethylene sheeting
- Stainless steel, plastic, or other appropriate composition bowl, scoop, spoon, trowel
- Laboratory-supplied sampling containers
- Labels
- Flags, stakes, paint
- Measuring wheel and tape measurer
- Photo-ionization detector (PID) or flame ionization detector (FID) and calibration equipment
- Stainless-steel hand auger
- Electronic pan scale and weights for calibration
- Syringes or other discrete soil core samplers
- Terra cores, cut-off syringes, or Encores and T-handle

Not all listed equipment may be necessary for a specific activity. Additional equipment may be required, depending on field conditions, requirements of the site-specific planning documents, or other planned sampling activities.

#### 3.0 PROCEDURES

The following soil sampling procedures are based on currently accepted techniques. The specific sampling protocols to be followed at a site may vary from what is specified herein based on the requirements of a state environmental agency, the U.S. Environmental Protection Agency, client need/request, or site/soil conditions and limitations. The site-specific planning documents should contain specific information on the sampling techniques, equipment, and protocols to be followed during soil sampling. Subsurface sampling (below 4 feet) requires adherence to utility clearance policies in the *Pre-Drilling Excavation Utility Checklist* (EnSafe, 2018) in Attachment A.

# 3.1 Instrument or Method Calibration

Calibration of a PID/FID is the only calibration anticipated for the sampling described in this SOP. However, if other instruments are used any necessary calibration must be conducted in the field (i.e., under the ambient climatic conditions that will be present during field sampling). Calibration of the PID/FID and any other monitoring instruments shall be performed in accordance with the manufacturer's specifications and results recorded in the in the field logs. Site-specific instrument calibration requirements should be specified in the project planning document.



# 3.2 Sample Collection

The following sections discuss the various soil sampling procedures, methods, equipment, and requirements that are typically employed.

# 3.2.1 General Soil Sample Collection and Screening

- At each soil sampling location, clear vegetation and debris, if necessary, and record the sampling location, identification number, and other location details. Record the weather conditions and other relevant onsite conditions.
- Verify that sampling equipment is properly decontaminated, in working order, and available.
- Place polyethylene sheeting on the ground and assemble all necessary sampling equipment on top of it. Cover surfaces with plastic onto which soils or sampling equipment will be placed (i.e., tables with polyethylene sheeting, truck tailgate). Samplers should use nitrile gloves during sample collection and handling. Change the gloves after each sample, or more frequently if needed.
- Once retrieved, open sampling devices and inspect the soil. If necessary, a screening and/or headspace sample reading for VOCs should be completed immediately upon opening the device. See Section 3.2.2 for a discussion of screening for VOCs.
- Prior to collecting soil samples, the soil should be observed and logged for color, texture, moisture, and signs of contamination (e.g., color, odor, stains).
- Record date/time, sample ID, and sample descriptions/screening results in the field logbook and/or the EnSafe Soil Boring Log, provided in Attachment A. A sketch or description of the location may also be recorded so the sample location can be re-constructed, especially if the location will not be recorded using global positioning satellite equipment. Where possible, take photographs of the sample and the sampling activities.
- Collect soil samples with stainless steel or disposable plastic scoops, spoons, or trowels from the sampling device(s) (split-spoon, liner, etc.). Place the samples in the appropriate containers. Soil should be placed in a stainless-steel bowl for homogenization for analytes other than VOCs.
- Immediately label the sample containers and place them on ice, if required for preservation. Complete the chain-of-custody form(s) as soon as possible.
- Dispose of all excess excavated soil in accordance with the site-specific planning documents.
- If required, mark the sample location with a clearly labelled wooden stake, steel pin, paint, or a pin flag. If the location is on a paved surface, the location may be marked with spray paint.
- Decontaminate the sampling equipment according to SOP FC-01 Decontamination of Field Equipment.

These procedures may require modification based on the specific type of sampling employed. If changes are made, they should be documented in the project logbook.



# 3.2.2 Screening and Sampling Soil for Volatile Organic Compounds

The following protocols are recommended for sampling and screening soil for VOCs. The sampling procedures outlined here are summarized from *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods SW-846, Method 5035.* 

# Soil Screening and Headspace for VOCs

Once retrieved, soil samples should be immediately screened for VOCs with a PID or FID, where required. Screening should be done with the sampling device and readings recorded. Sample screening can be done using the following general procedures:

- Expose the soil to the sampler.
- Make a hole in the soil with a decontaminated sampling tool and place the PID/FID inlet very close to the hole. Be very careful not to get soil on the tip of the PID/FID.
- Take PID/FID readings every 4 to 6 inches along the soil in the sampler and/or in any areas
  of stained or disturbed soil. Shorter intervals may be needed depending on the length of
  sample recovered.
- Record the highest PID/FID reading and the depth at which it was observed along with all other pertinent observations on the sampling/boring log.

If required, immediately collect a soil sample for headspace screening. Headspace samples can be collected and placed in either a sealable plastic bag or a 2- or 4-ounce glass jar. Consult the site-specific planning documents, project chemist, or project manager for exact methods to be used. Once contained, allow the samples to rest for 15 to 20 minutes. This interval gives time for organic compounds to volatilize into the container from the soil. When the time has passed, open the bag or jar and immediately take readings of the headspace. Record the maximum reading.

### Soil Sampling for VOCs

Soil for VOC analyses may be collected using any of the sampling methods described in this SOP. Soil samples may be collected in a standard 2-to 4-ounce soil VOC container, syringes, or Terra Core or EnCore samplers. Consult the site-specific planning documents, project chemist, or project manager for methods to be used. The various sampling methods are discussed below.

#### Bulk Jar VOC Collection

Soil samples may be collected directly into 2- and 4-ounce glass jars. Be aware that samples for VOC analysis collected in bulk jars are not condoned by regulatory agencies because of VOC loss. However, it may be appropriate to collect soil in bulk jars for waste analysis. If soil is collected in bulk jars, it should be packed tightly in the jar with no headspace allowed, and then the cap sealed tightly onto the jar. Always use properly decontaminated utensils for packing soil in the jar. Do not used gloved hands to pack soil. The 2- and 4-ounce soil sample jars are typically labeled and then the soil is packed tightly into the jar with zero headspace. Once filled and labeled, the jar is placed in a single bubble wrap bag which is then placed into a plastic bag and sealed after the air is pushed from the bag.



# Syringe and Terra Core Sampling

For soils collected using a syringe or Terra Core, a closed system is maintained. From collection through analysis, the sample bottles are not opened. The bottle kit for a routine VOC analysis will typically include three 40-milliliter (mL) VOC vials and one glass jar. Two 40-mL VOC vials will contain either 5 mL reagent water or 5 mL sodium bisulfate and magnetic stir bars (i.e., low-level vials). Note: Soil collected in reagent water has a 24-hour holding time and samples should be delivered daily/shipped nightly. The third vial will contain methanol with no magnetic stir bar (i.e., high-level vial). The vials are provided by the laboratory and are pre-weighed, with the tare weight recorded on the affixed sample label. Note: <u>Do not</u> affix other labels to the vials because addition of a label would alter the vial weight. All information is recorded directly on the affixed sample label using an indelible marker. The soil jar is provided for percent solids determination. For VOC analysis, samples are collected prior to sample homogenization in accordance with the procedure described below.

- 1. Determine the soil volume necessary for the required sample weight (typically 5 grams):
  - a) Prepare a 5-mL sampling corer (e.g., Terra Core) or cut-off plastic syringe.
  - b) Draw back the plunger to the 5-gram mark or 5-mL (5 cubic centimeters [cc]) mark on cut-off syringe and insert the open end of the sampler into an undisturbed area of soil with a twisting motion, filling the sampler with soil. Note the location of the plunger with respect to the milliliter (cc) or other graduation printed on the sampler.
- 2. Once the required soil volume has been determined, pull the plunger back to this mark and hold it there while filling the syringe for each sample.
- 3. Collect 5 grams of soil using the cut-off syringe or Terra Core sample device. Extrude the 5-grams of soil into one of the low-level 40-mL vials. Quickly wipe any soil from the threads of the vial with a clean Kimwipe and immediately close the vial. It is imperative that the threads be free from soil or other debris prior to replacing the cap on the vial in order to maintain the closed system necessary for the analysis. Note: When using the syringes, it is important that air is not allowed to become trapped behind the sample prior to extrusion, as this will adversely affect the sample.
- 4. Gently swirl the vial so that all soil is fully wetted with the preservative.
- 5. Fill the other low-level vials in this manner.
- 6. Repeat the process for the high-level vial, the mass of soil in grams should be identical to the volume of methanol in mL (i.e., 1:1 ratio of soil to methanol).
- 7. Collect any additional quality control sample (e.g., field duplicate, matrix spike, and matrix spike duplicate) in the same manner as above.
- 8. Fill the jar with soil from the same area for percent moisture determination.
- 9. Returns all vials to the foam rubber holder and place a sealed plastic bag around the foam rubber holder for shipment.



# EnCore Sampling

When sampling directly with the EnCore Sampler, a stainless-steel T-handle holds the sampler, and it is pushed into the soil and filled. The container is removed from the T-handle and must be immediately capped and locked. Three EnCore samples are typically collected, and a bulk jar is filled from the same area for moisture determination. After collecting the sample using the EnCore, it must be stored in an ice chest and cooled immediately. Once the EnCore is filled, the sample is capped, locked, and placed in the original foil bag. All foil bags containing EnCore samplers are then labeled and placed in a plastic bag. The bag can be sealed with a custody sticker, if required.

# Intermediate VOC Sample Container

A soil sample for VOC analysis may also be collected with conventional sampling equipment and placed in an intermediate sample container (2-ounce lidded glass jar or similar) to be held while a soil boring hole is completed. Once completed, a sample for analysis is selected and placed in one of the final sample containers discussed here. If an intermediate container is used, the sample must be transferred to the final sample container as soon as possible within 30 minutes.

# Special Considerations when Sampling for VOCs

If samples are to be analyzed for VOCs, they should be collected in a manner that minimizes disturbance of the sample. For example, when sampling with an auger, the sample for VOC analysis should be collected directly from the auger bucket (preferred) or from minimally disturbed material immediately after an auger bucket is emptied into the pan. *Samples for VOC analysis are not homogenized*. Preservatives may be required for some VOC samples. Consult the method or the project chemist to determine if other preservatives are necessary.

When using stainless steel spoons, if the soil being sampled is cohesive and holds its in situ texture in the spoon, the EnCore or Terra Core Sampler or syringe used to collect the sub-sample for VOCs should be collected directly from the spoon. If, however, the soil is not cohesive and crumbles when removed from the ground surface for sampling, consideration should be given to plugging the sample directly from the ground surface at a depth appropriate for the investigation, where possible.

#### 3.2.3 Surface and Shallow Subsurface Soil Sampling

The methods discussed here are used to collect surface and shallow subsurface soil samples. Surface soils are generally classified as soils between the ground surface and 6 to 12 inches below ground surface (bgs). The most common interval is 0 to 6 inches bgs; however, the data quality objectives of the investigation or regulatory instructions may dictate another interval, such as 0 to 3 inches bgs or 0 to 2 feet bgs for risk assessment purposes. The shallow subsurface interval may be considered to extend from approximately 12 inches bgs to a site-specific depth at which sample collection using manual methods becomes impractical.

The following procedures are recommended for collecting surface soil samples. Gently scrape any vegetative covering until soil is exposed. Completely remove any pavement (e.g., gravel, asphalt). The depth measurement for the sample begins at the top of the soil horizon, immediately following any removed materials.

 After putting down plastic sheeting in the sampling area and clearing the immediate surface soil, collect soil from the exposed sampling area with a decontaminated trowel, spoon, hand auger, or shovel for non-VOC analyses. With the PID/FID, monitor the breathing zone and



sampling area, and screen the samples as required. In addition, monitor the shallow excavation directly.

2. For VOC analysis, collect representative soil samples directly from the recently exposed soil using a syringe or other soil coring device and place in containers (e.g., Terra Core, EnCore, glass jar). In addition, use the other procedures discussed in Section 3.2. 2.

When compositing non-VOC samples, make sure that each composite location (aliquot) consists of equal volumes.

Stainless steel spoons, scoops, or trowels may be used for surface soil sampling to depths of approximately 6 inches bgs where conditions are typically soft and non-indurated, and there are no vegetative layers to penetrate.

# **Hand Augers**

Hand augers may be used to advance boreholes and collect soil samples in the surface and shallow subsurface intervals. Samples can be collected directly from the auger. Typically, 3- to 4-inch stainless steel auger buckets with cutting heads are used. The bucket is advanced by simultaneously pushing and turning using an attached handle with extensions (as needed). Auger holes are advanced one bucket at a time until the sample depth is achieved, or the auger cannot continue due to refusal/resistance. Other considerations for hand auger sampling include the following.

- Observe precautions for collection found in the discussion of sampling for VOCs in Section 3.2.2. Because of the tendency for the auger bucket to scrape material from the sides of the auger hole while being extracted, the top several inches of soil in the auger bucket should be discarded prior to directly collecting VOC samples from the bucket and placing the remaining bucket contents in the homogenization container for processing.
- When moving to a new sampling location, the entire hand auger assembly must be properly decontaminated.

When augering with a pin-style auger, continually inspect the auger for loose pins. The auger may need to be decontaminated between sample depths in the same hole. Consult the site-specific planning document or project manager to determine if this is required.

# 3.2.4 Direct Push Soil Sampling

The methods discussed here employ a direct push technology (DPT) drilling rig. The DPT sampling methods are used primarily to collect deeper subsurface soil samples (below 4 feet bgs). When using the DPT rig, the location should be cleared for utilities to a depth of 4 feet using a stainless-steel hand auger. Samples to 4 feet can be collected from the hand auger. All of the DPT sampling tools collect and retrieve soil from within a disposable plastic, thin-walled liner. Samples can be collected directly from the liner.

Any pavement (e.g., gravel, concrete) present at or near the surface should be removed before the sample is collected. The depth measurement for the sample begins at the top of the soil horizon, immediately following any removed surface materials. Turf grass is not typically removed prior to sampling with these devices.



# **Macro-Core Soil Sampler and Dual Tube System**

The Macro-Core sampler is a solid barrel direct-push sampler equipped with a piston-rod point assembly used primarily for collection of either continuous or depth-discrete subsurface soil samples. Although other lengths are available, the standard Macro-Core sampler is capable of recovering a discrete sample core 45 inches by 1.5 inches contained inside a removable acetate liner.

The Dual Tube 21 soil sampling system is a direct-push system for collecting continuous core samples of unconsolidated materials from within a sealed outer casing of 2.125-inch outer diameter probe rod. The outer casing is advanced, one core length at a time, with only the inner probe rod and core removed and replaced between samples.

# Other Considerations When Using Direct Push Sampling Methods Liner Use and Material Selection

Direct-push soil samples are collected within a liner to facilitate removal of sample material from the sample barrel. The liners may only be available in a limited number of materials for a given sample tool but are generally available in brass, stainless steel, cellulose acetate butyrate, polyethylene terephthalate glycol, polyvinyl chloride, and Teflon. For most investigations and assessments, the standard polymer liner material for a sampling tool will be acceptable. When the study objectives require very low reporting levels or involve unusual contaminants of concern, the use of more inert liner materials such as Teflon or stainless steel may be necessary.

# Sample Orientation

When liners and associated samples are removed from the sample tubes, it is important to maintain the proper orientation of the sample. This is particularly important when multiple sample depths are collected from the same push. It is also important to maintain proper orientation to define precisely the depth at which an aliquot was collected. Maintaining proper orientation is typically accomplished using vinyl end caps. Convention is to place red caps on the top of the liner and black caps on the bottom to maintain proper sample orientation. Orientation can also be indicated by marking on the exterior of the liner with a permanent marker.

### Core Catchers

Occasionally the material being sampled lacks cohesiveness and is subject to crumbling and falling out of the sample liner. In those cases, the use of core catchers on the leading end of the sampler may help retain the sample until it is retrieved to the surface. Core catchers may only be available in specific materials and should be evaluated for suitability. However, given the limited sample contact that core-catchers have with the sample material, most standard core-catchers available for a tool system will be acceptable.

#### Decontamination

The cutting shoe and piston rod point are to be decontaminated between each sample, using the procedures specified in SOP FC-01 Decontamination of Field Equipment. Within a borehole, the sample barrel, rods, and drive head may be subjected to an abbreviated cleaning to remove obvious and loose material but must be cleaned between boreholes using the procedures for downhole drilling equipment specified in SOP FC-01 Decontamination of Field Equipment.

# 3.2.5 Split-Spoon Drill Rig Methods

Split-spoon sampling methods completed with a drilling rig are primarily used to collect shallow and



deep subsurface soil samples. All split-spoon samplers, regardless of size, are basically split cylindrical barrels threaded on each end. The leading end is held together with a beveled threaded collar that functions as a cutting shoe and is pushed and drilled into the soil.

# **Standard Split Spoon**

The drill string is advanced to the sampling depth and removed, and a standard split spoon is attached to a string of drill rod. Split spoons used for soil sampling must be constructed of stainless steel and are typically 2 inches outer diameter (1.5 inches inner diameter) and 18 to 24 inches in length. A safety hammer is then used to drive the split spoon into the soil at the bottom of the borehole. After the split spoon has been driven into the soil, filling the spoon, it is retrieved to the surface, where it is removed from the drill rod string and opened for sample collection using the procedures discussed in Sections 3.2.

# **Continuous Split Spoon**

The continuous split spoon is a large-diameter split spoon that is advanced into the soil column inside a hollow stem auger. Continuous split spoons are typically 3 to 5 inches in diameter and 5 or 10 feet in length. After the auger string has been advanced into the soil column, the sampler is removed, then opened for soil screening and sample collection using the procedures discussed in Section 3.2.

# 3.2.6 Rotosonic Soil Sampling

Sampling soil with a rotosonic drilling rig produces a continuous core. When using rotosonic drilling techniques, a core barrel 10 feet long is advanced to the sampling depth and collects a sample in the interior of the barrel. Override casing is then run over the core barrel, and the core barrel is then retracted and brought to surface with soil in it. At the surface, the core is extruded with the assistance of resonance vibration along the core barrel. The core is extruded into plastic bags cut to lengths between 3 to 5 feet for ease of handling. Core sample sizes can range from 3 to 8 inches in diameter. Samples can be collected directly from the plastic bags using the procedures in Section 3.2.

### 3.2.7 Shelby Tube and Thin-Walled Sampling Methods

Shelby tubes, also generically referred to as thin-walled push tubes or Acker thin-walled samplers, are used to collect subsurface soil samples in cohesive soils and clays during drilling activities. In addition to samples for chemical analyses, Shelby tubes are also used to collect relatively undisturbed soil samples for geotechnical analyses, such as hydraulic conductivity and permeability, to support hydrogeologic characterizations at hazardous waste and other sites.

If pavement (e.g., gravel, concrete) is present at or near the surface, it should be removed before the sample is collected. The depth measurement for the sample begins at the top of the soil horizon, immediately following any removed materials. Turf grass is not typically removed prior to sampling with this device.

A typical Shelby tube is 30 inches in length and has a 3-inch outer diameter (2.875-inch inner diameter) and may be constructed of steel, stainless steel, galvanized steel, or brass. They also typically are attached to push heads that are constructed with a ball check to aid in holding the contained sample during retrieval. If used for collecting samples for chemical analyses, the Shelby tube must be constructed of stainless steel. If used for collecting samples for standard geotechnical parameters, any material is acceptable. If samples for chemical analyses are needed, the soil



contained inside the tube is then removed for sample acquisition once the sampler is deployed and retrieved. Samples can be collected directly from the tube using the procedures discussed in Section 3.2. If the sample is collected for geotechnical parameters, the tube is typically capped, maintaining the sample in its relatively undisturbed state, and shipped to the appropriate geotechnical laboratory.

# 3.2.8 Backhoe Sampling

Backhoes may be used to collect surface and shallow subsurface soil samples. The trenches created by excavation with a backhoe offer the capability of collecting samples from very specific intervals and allow visual correlation with vertically and horizontally adjacent material. The sample should be collected without entering the trench.

# **Scoop-and-Bracket Method**

If a sample interval is targeted from the surface, it can be sampled using a stainless-steel scoop and bracket. First, a scoop and bracket are affixed to a length of conduit that is lowered into the backhoe pit. The scoop is used to scrape away the soil comprising the surface of the excavated wall. This material likely represents soil that has been smeared by the backhoe bucket from adjacent material. After the smeared material has been scraped off, the original stainless-steel scoop is removed, and a clean stainless-steel scoop is placed on the bracket. The clean decontaminated scoop can then be used to remove a sufficient volume of soil from the excavation wall to make up the required sample volume. Samples can be collected directly from the scoop using the procedures discussed in Section 3.2.

#### **Direct-from-Bucket Method**

It is also possible to collect soil samples directly from the backhoe bucket at the surface. Some precision with respect to actual depth or location may be lost with this method but if the soil to be sampled is uniquely distinguishable from the adjacent or nearby soils, it may be possible to characterize the material as to location and depth. In order to ensure representativeness, it is also advisable to dress the surface to be sampled by scraping off any smeared material that may cross-contaminate the sample. Samples can be collected directly from the bucket using the procedures discussed in Section 3.2.1.

# Special Considerations When Sampling with a Backhoe

The following should be considered when sampling with a backhoe.

- Do not physically enter backhoe excavations to collect a sample. Use alternative methods as discussed.
- Smearing is an important issue when sampling with a backhoe. Measures must be taken, such as dressing the surfaces to be sampled, to mitigate problems with smearing.
- Paint, grease and rust must be removed, and the bucket decontaminated prior to sample collection.

### 3.3 Sample Handling and Preservation

The site-specific planning documents should specify sample handling and preservation procedures for the samples to be collected at a specific site. The contracted laboratory should specify the types and numbers of containers to be used and the required preservatives, if applicable. The planning



documents and/or laboratory should detail sample holding times, which are important to know if samples are not going to be hand-delivered or shipped overnight to the laboratory. Unless otherwise specified by the contracted laboratory, all samples shall be thermally preserved to  $4^{\circ}$ Celsius (°C)  $\pm 2^{\circ}$ C immediately upon collection.

Correctly labeled sample containers will be placed in resealable plastic bags to prevent cross-contamination, wrapped in bubble wrap (or packed with appropriate inert packing material) to prevent breakage, and placed in iced coolers to maintain the preservation temperature of  $4^{\circ}\text{C} \pm 2^{\circ}\text{C}$ . Correctly completed chain-of-custody forms, using SOP AD-02 Sample Labelling and Chain-of-Custody, will accompany all samples delivered or shipped to the contracted laboratory. Those processes ensure the integrity of the samples from the time of collection through sample disposal. All coolers will be packaged using SOP FM-01 Packaging and Shipping Procedures and sealed with chain-of-custody seals before shipment or hand delivery. The site-specific planning documents for may require chain-of-custody seals to be placed on individual sample containers.

# 3.4 Sample Analysis

Sample analytical requirements should be considered when determining the sampling method and equipment to employ. The specific sampling protocols to be followed at a particular site may vary from what is specified herein based on the requirements of a state environmental agency, U.S. EPA Region, client need/request, equipment, site conditions, and limitations. The site-specific planning documents should contain specific information on the sample analysis to be conducted and the sampling methods to be employed.

### 4.0 DATA ACQUISITION, CALCULATIONS, AND DATA REDUCTION

Data is acquired in the field or office from the collection and analysis of samples. Other field data and observations are gathered and should be recorded in sampling notes and logs.

### 5.0 DATA/RECORDS MANAGEMENT

Information generated or obtained by field personnel will be organized and accounted for in accordance with established records management procedures found in SOP FD-01 Field Documentation or as specified in the project sampling and analysis plan. Field notes recorded in a bound field logbook will be generated, as well as chain-of-custody documentation and photographs, then stored in the project files.

# 6.0 QUALITY CONTROL AND QUALITY ASSURANCE

Quality assurance and quality control procedures shall adhere to requirements in project quality assurance plans, sampling and analysis plan, and other site-specific planning documents.

# 7.0 NONCONFORMANCE AND CORRECTIVE ACTION

Nonconformance with this SOP may require corrective action as deemed necessary by the quality assurance manager or project manager. Notes, logs, and work will be reviewed periodically to ensure compliance.

#### 8.0 REFERENCES

EnSafe Inc. Corporate Health and Safety Plan. Memphis, Tennessee. March 2009.

EnSafe Inc. Corporate Safety Management System. Memphis, Tennessee. May 2014.



- Resolution Consultants, *Surface and Subsurface Soil Sampling Procedures, Procedure 3-21*, Revision 0, May 2012.
- U.S. Environmental Protection Agency, *Description and Sampling of Contaminated Soils A Field Pocket Guide. U.S. EPA EPA/625/12-91/002.* Cincinnati, Ohio. November 1991.
- U.S. Environmental Protection Agency. *Soil Sampling SESDPROC-300-R3*. Effective Date August 21, 2014. Retrieved from: https://www.epa.gov/sites/production/files/2015-06/documents/Soil-Sampling.pdf.

# Attachments — Forms, Checklists, and Data Sheets

Author	Reviewer(s)	Revisions (Technical or Editorial)
Dave Fuehrer	Tina Cantwell	Revision 0 — February 2020 (Initial Issue)
	Holly Brauer	Revision 1 – June 2020 (Editorial)

Attachment A
Utility Location Checklist and Boring Log



# PRE-DRILLING/EXCAVATION UTILITY CHECKLIST (COMPLETE IN ADDITION TO THE SWAP) Site Name & Address:

site iva	me & Address:			
	Project Number & Manag			
	ed Date of Field Work & I			
		AFTER fieldwork has been completed:	ibi a a	
		planning stages (B)=To be accomplished onsite before fieldwork activ		
		BLIC AND PRIVATE PROPERTY) REQUIREMENTS	YES	NO
		or One Call" been notified to mark the locations of all underground of Fieldwork is Extended Past 2 Weeks After Inquiry.		
2(A).	One-Call Ticket Info.	Date Called: One-Call Phone#:		
(	REQUIRED BY LAW).			
		Beginning & Expiration Date/Time:		
		Entities to be contacted separately:		
2/40	D) 11 6			
		her relevant) personnel been interviewed and asked to provide copies		
		s and drawings about underground utilities near the excavation area?		
		ough been accomplished to identify surface indicators of utilities?		
		ns of underground utilities been marked on the surface by one-call		
		Id personnel understand how these utilities traverse underground?		
	-	f utilities been inserted on the work area drawing(s)?		
		mation concerning the type/location/depth of known underground		_
		esponsible supervisor or contractor at the work site for review and		
	ole offset/relocation?			
		d pipe locating devices (PM/Qualified Safety Review approval)		
	used to confirm position			
		neter" tools been used to dig trial holes (minimum depth of 4 FEET		
		minimum diameter of downhole sampling tool, including any		
		lly identify position/depth of the underground utilities, or to determine		
		within the test location? Depending on regional subsurface (Depth of		
		nditions, unground utilities may be buried deeper than 4 feet. All		
		depth shall be documented at the bottom of this page.		
EXCAVATION ONLY		ration (at all times), a watch is kept for evidence of cables, pip	es, or	otner
)L X	underground utilities no	ot previously identified.		
N A	dd(D) If have a suit		1	- l
C C		pment is required to cross an area where underground utilities are	known	to be
Ω	present, the cross poin	its are kept to a minimum and are clearly marked.		
	Please refer to the back	k of this form for explanations and tips on how to answer the question	ıs listec	abov
		this checklist for comments/concerns to any of these questions an		
		er for the specific State/Region that fieldwork is performed.	•	
	,	, , , , , , , , , , , , , , , , , , , ,		
	<b>A Qualified Safety R</b>	Reviewer MUST be consulted and approve this site-specific t	<u>form E</u>	<b>EFOR</b>
	fieldwork may comm	nence if the answer to ANY Question on the checklist is NO.	This a	approv
		erson) may be obtained/received immediately prior to starting work of		
	advanced noticed is pre	eferred to allow the reviewer time to look at maps/drawings of the sit	e and a	all othe
	relevant documents.			
<u>Checkl</u>	ist Submitted By:	Qualified Safety Review (I	f Need	<u>led):</u>
Name:_		Name:		
Signatu	re:	Signature:		
Jigi iatu		Signatule:		
Date:		Date:		



# PRE-DRILLING/EXCAVATION UTILITY CHECKLIST (EXPLANATIONS AND TIPS)

The instructions below have been developed to assist field personnel in accomplishing the tasks on the front of this form. If at any time field personnel are unclear on how to perform these necessary pre-job steps, refer to the Qualified Safety Reviewer list on the EnSafe Intranet.

(A)=To be accomplished during planning stages (B)=To be accomplished onsite before fieldwork activities

### **UNDERGROUND UTILITIES (PUBLIC AND PRIVATE PROPERTY)**

**1(A).** This is REQUIRED no matter if the work area is on public or private property. Borings/excavations should be located onsite before One-Call notification, if possible, with WHITE paint/flagging. **Update One-Call every 2 weeks, and locators need 3 working days to mark all utilities within the work area.** 

**2(A).** This may be accomplished by telephone/internet. Most state-specific one-call agencies are open 8AM-5PM local time, Monday thru Friday.

**3(A&B).** This may happen the morning of the drilling/excavation activities to be performed. All personnel need to be aware of underground utilities within (or near) the work area. Offsets may be performed to minimize the probability of encountering underground utilities.

**4(B).** Example: light posts, valve pits, pit covers, curb/gutter inlets, manholes, surface indentations, saw cut areas, etc. This is best performed during the pre-bid site visit, but may be performed immediately before activities.

**5(B).** One-Call color markings typically are as follows: WHITE (Excavation/Borings), RED (Power/Electrical), YELLOW (Gas/Petroleum), ORANGE (Communication/Fiber Optics), BLUE (Potable Water), GREEN (Sanitary/Storm Sewer). Review all colors and positions with field personnel prior to beginning drilling/excavating.

**6(A&B).** This refers to simply looking at the underground utilities onsite and plotting them (by hand initially) on the site drawing or aerial.

**7(B).** If NO, please explain. After all underground utilities have been plotted on the drawing, review the locations with the EnSafe PM, all personnel (including subcontractors), and the client if deemed necessary. This will help to orient all field personnel as to the location of the underground utilities within or near work operations. If the utilities are marked within a 3 horizontal feet lateral distance of the boring/excavation, offsets SHOULD be considered.

**8(B).** This refers to the use of a private utility locator to assist in locating underground utilities on private property that haven't been located by the One-Call system. This is highly dependent upon the makeup of the underground utility (metal, plastic, clay terra cotta, etc.) and complications due to rebar within concrete, multiple utilities crossing points, etc. Only previously trained personnel (most likely private utility locator and/or geophysical subcontractors) should use these devices. The Qualified Safety Reviewer AND the EnSafe PM AND the client will make the decision TOGETHER if a private utility locator is required.

**9(B).** Example — hand augers, probe rod, vacuum extraction, post-hoe digger, etc. This is NON-NEGOTIABLE for drilling activities. Every boring must be advanced (without mechanical means) to a depth of four (4) feet below ground surface (or maximum boring depth if boring terminal depth is less than 4 feet). Only exception is where large boulder or bedrock in within the top 4 feet of the boring. Boring may be halted at a depth less than 4 feet if it is confirmed and documented that the boring is blocked by rock with apparent diameter greater than that of the boring/trial hole.

EXCAVATION ONLY

**10(B).** This is site-specific, but usually no closer than 3 horizontal feet from any and all underground utilities (especially lines with high pressure or voltage/flammable/combustible substances). The safe distance for overhead utilities is 10 horizontal - 10 vertical feet (up to 50kV). Stay alert at all times. All personnel (EnSafe and Subcontractors) have stop work authority in reference to underground utilities. No job is too important to compromise safety.

**11(B).** The depth/alignment of the underground utility to be crossed should be determined to prevent damage to each buried utility.

#### Insert Field Notes/Concerns Here:



# **Subsurface Utility Location Team Members**

Memphis, TN – Wesley Goodnight, Dave Fuehrer, Joe Matthews, Jason Broughton,

Ben Brantley

Nashville, TN – Tammy Williams, Greg Olin, Troy Estes

Knoxville, TN – Brian Caldwell

Charleston, SC – David Warren

Bowling Green, KY – David Doyle, Ric Federico

Cincinnati, OH – Jim Rathbone

Cleveland, OH – Ned Baker, Wendy Zayac

Dallas, TX – Tom Wiberg, Jay Spence

Hartford, CT - Rob McCarthy

Londonderry, NH - Robert Francis

Jackson, MS – Brian Derry

Pleasant Hill, CA – Jim Madden

Jacksonville, FL – Frank McInturff

Additional Corporate Resources – Paul Stoddard, Jay Spence, Jeff James, David Farrell

ENS/IFE	Sketch of Boring Location	Location ID:
		of
Ollinat		Start Date/Time:
Client:		End Date/Time: Total Depth:
Project #:		Sample Method:
Purpose:		Drill Equip:
Project:		Drilling Co.:
Location:		Geologist:
Number Interval Interval Inches Recovered Inches Inches Inches Inches Ova Reading (ppm)  USCS  USCS	Lithologic Des	
Mumber Interval Interval Inches Recovered Inches In	Visual-Manual De	
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Notes:	Well Constuction		Тор	Base	Sample ID	Time	Interval	Analyses
	Material:	Casing:			1)			
	Diameter:	Screen:			2)			
	Wellhead:	Grount:			3)			
	Ballards:	Bent/Seal:			4)			
	Pad:	Sand Pack:			5)			

# Standard Operating Procedure Manual Measurement of Water Levels in Wells

These standards will ensure continuity within the organization.

#### **Preamble**

This standard operating procedure (SOP) is designed to provide the user procedures on how to manually measure water levels in wells. Before using this SOP and as part of the due diligence, the user is required to determine whether state and federal water level collection standards need to be met. If a difference exists between the SOPs herein and the state and/or federal SOPs, the state and federal SOPs takes precedent. If this SOP is modified per agreement between parties associated with field activities, the agreed changes will become part of the SOP and the modifications will be appended to this SOP for the record.

This SOP describes the activities and responsibilities pertaining to collecting water levels in wells. If possible, or as soon as reasonably possible, deviations from this SOP must be approved by the parties responsible for this task; i.e., Project Manager and/or Program Quality Manager.

#### 1.0 PURPOSE AND SCOPE

# 1.1 Purpose

This document describes general and specific procedures, methods and considerations to be used and observed when determining water levels in wells and total depths of wells.

# 1.2 Scope/Application

The procedures contained in this document are to be used by field investigators to measure water levels and depths of wells. On the occasion that field investigators determine that any of the procedures described in this section are either inappropriate, inadequate or impractical and that another procedure must be used for water level or depth determination, the variant procedure(s) will be documented in the field log book and the subsequent investigation report, along with a description of the circumstances requiring its use.

#### 2.0 SAFETY

Proper safety precautions must be observed when measuring water levels in wells and determining their depths. Refer to the EnSafe Corporate Health and Safety Plan (HASP), the Project HASP, Job Hazard Analysis and SWAP for guidelines on safety precautions. These guidelines, however, should only be used to complement the judgment of an experienced professional. Field investigators must address chemicals that pose specific toxicity or safety concerns and follow any other relevant requirements, as appropriate.

# 3.0 TERMS AND DEFINITIONS

None.

#### 4.0 ROLES AND RESPONSIBILITIES

# 4.1 Project Manager

The Project Manager or project designee will be administratively responsible for ensuring water level measurements are carried out per this SOP. It is the project manager's responsibility to certify that the Site Specific Work Plan with this SOP has been read by all field personnel conducting the field activities, and that they understand all procedures contained therein. The project manager or designee will conduct periodic audits over the course of the project to make sure the Work Plan and these procedures are being followed.

# 4.2 Field Manager

The Field Manager is responsible for ensuring that all field personnel follow these procedures and that the water level measurement procedures are completed according to this SOP. As time permits, the Field Manager should conduct periodic inspections of the field techniques by field personnel.

Before field tasks begin and after field tasks are complete the Field Manager will inspect field equipment to make sure equipment is in working order and has been properly decontaminated.

The Field Manager will report any deviations from this SOP to the Project Manager or the Program Quality Control Manager, then document in the field logbook, and associated report or equivalent document.

# 4.3 Program Quality Manager

The program Quality Manager is responsible for ensuring overall compliance with this procedure and may request project audits to make sure procedures are being followed.

## 4.4 EnSafe Field Personnel

All field personnel must read and be familiar with this SOP. They are responsible for conducting water level measurement procedures according to this SOP and the Site Specific Work Plan. If, based on their best professional judgment, procedures in this SOP need to be modified in the field, the field manager will be notified of any deviations and the changes will be recorded in the field logbook. If the field manager cannot be contacted, then the project manager should be notified.

#### 5.0 EQUIPMENT AND SUPPLIES

The following equipment is required for the collection of measurements:

- Electronic Water Level Indicator consisting of a spooled, two-wired electrical sounder or conductivity meter equipped with sufficient cable to reach the deepest water level. The cable should be graduated in 0.01-foot intervals.
- Weighted steel measuring tape.
- Extra batteries for meter (typically 9-volt).
- Decontamination supplies including a bucket, brush, soap or solvent cleaner depending upon contaminant, potable/deionized/distilled water, spray bottles, paper towel, and plastic sheeting.

- Keys for casing locks and tools needed to enter casings or flush-mounted well heads or vaults,
- Log book, well forms and pens
- Safety equipment and personal protective equipment (PPE).

#### 6.0 WATER LEVEL AND DEPTH MEASUREMENT PROCEDURES

#### 6.1 General

The measurement of the groundwater level in a well is frequently conducted in conjunction with ground water sampling to determine the "free" water surface. This potentiometric surface measurement can be used to establish ground water direction and gradients. Groundwater level and well depth measurements are needed to determine the volume of water or drawdown in the well casing for proper purging. All groundwater level and well depth measurements should be made relative to an established reference point on the well casing and should be documented in the field records. This reference point is usually identified by the well installer using a permanent marker for PVC wells, or by notching the top of casing with a chisel for stainless steel wells. By convention, this marking is usually placed on the north side of the top of casing. If no mark is apparent, the person performing the measurements should take both water level and depth measurements from the north side of the top of casing and note this procedure in the field logbook. To be useful for establishing groundwater gradient, the reference point should be tied in with the NGVD (National Geodetic Vertical Datum) or a local datum.

For an isolated group of wells, it is acceptable to use an arbitrary datum common to all wells in that group. Water levels should be allowed to equilibrate prior to measurement after removing sealing caps. There are no set guidelines and appropriate equilibration times can range from minutes to hours depending on well recharge, local geology and topography, and project objectives.

# 6.2 Procedural Precautions

The following precautions should be considered when measuring water levels and depths of wells:

- Special care must be taken to minimize the risk of cross-contamination between wells when conducting water level and depth measurements. This is accomplished primarily by:
- 1. Decontaminating the sounders or other measuring devices between wells according to the SOP for Field Equipment Cleaning and Decontamination
- 2. Maintaining the sounders in clean environment while in transit between wells
- 3. If known, measuring cleanest well locations first and then moving to more contaminated locations
- Water levels and well depths measured according to these procedures should be recorded in a bound logbook dedicated to the project consistent with the SOP for Logbooks.
- Serial numbers, property numbers or other unique identification for the water level indicator or sounder must also be recorded.

- If multiple field teams are used to collect measurements across a large site, then each team should measure the same well, sequentially, at the start of the event to ensure that consistent measurements are being obtained.
- If available, prior measurement event results should be obtained and reviewed by the field investigation team.

# 6.3 Specific Groundwater Level Measurement Techniques

Measuring the depth to the free ground water surface can be accomplished by the following methods. Method accuracies are noted for each of the specific methods described below.

- Electronic Water Level Indicators These types of instruments consist of a spool of dual conductor wire, a probe attached to the end and an indicator. When the probe comes in contact with the water, the circuit is closed and a meter light and/or audible buzzer attached to the spool will signal contact. Penlight or 9-volt batteries are normally used as a power source (note: extra batteries should be available). Measurements should be made and recorded to the nearest 0.01 foot.
- Other Methods There are other types of water level indicators and recorders available
  on the market, such as weighted steel tape, chalked tape, sliding float method, airline
  pressure method and automatic recording methods. These methods are primarily used
  for closed systems or permanent monitoring wells. Acoustic water level indicators are
  also available which measure water levels based on the measured return of an emitted
  acoustical impulse. Accuracies for these methods vary and should be evaluated with
  respect to project objectives before selection. Any method not capable of providing
  measurements to within 0.1 foot should not be used.

#### 6.4 Sites with a Shallow Groundwater Gradient

Groundwater gradients at some sites can be very shallow and if gradient and groundwater flow pattern (gradient direction) determination are part of the project objectives, it is critical that groundwater level measurements obtained from wells are as accurate as possible. Special care should be taken to allow the water level to equilibrate after removing sealing caps and the same sounder/meter should be used for all measurements, if possible. The sounding activity should be coordinated to allow all wells to be sounded within the minimum possible time. This is particularly important in areas with potential tidal influences.

#### 6.5 Total Well Depth Measurement Techniques

The well sounder, weighted tape or electronic water level indicators can be used to determine the total well depth. This is accomplished by lowering the tape or cable until the weighted end is felt resting on the bottom of the well. Because of tape buoyancy and weight effects encountered in deep wells with long water columns, it may be difficult to determine when the tape end is touching the bottom of the well and sediment in the bottom of the well can make it difficult to determine total depth. Care must be taken in these situations to ensure accurate measurements.

For total depth measurement, the operator may find it easier to allow the weight to touch bottom and then detect the 'tug' on the tape while lifting the weight off the well bottom.

All total depth measurements must be made and recorded to the nearest 0.1 foot.

As a cautionary note, when measuring well depths with the electronic water level indicators, the person performing the measurement must measure and add the length of the probe beneath the circuit closing electrodes to the depth measured to obtain the true depth. This is necessary because the tape distance markings are referenced to the electrodes, rather than the end of the probe.

## 7.0 ESTABLISHMENT OF TOP OF CASING ELEVATIONS

To establish groundwater surface elevations, the measured distance from the top of casing to the water surface is subtracted from the well top of casing (TOC) elevation. Obtaining accurate TOC elevations is crucial to developing an accurate groundwater surface elevation map and determination of groundwater flow direction. The only acceptable means of surveying well TOC elevations is differential leveling conducted to third order standards. This work must be conducted with an auto level as the leveling instrument. Surveying TOC elevations with a total station or survey-grade GPS will not provide the requisite accuracy. When adding wells to a monitoring network, it is permissible to tie the new well elevations to the known TOC elevations of existing wells in the network. The elevations of several wells in the existing network should be checked to assure that the relative differences in elevation match the recorded elevation data. Generally, the ground surface elevations at each well should be surveyed at the same time.

## 8.0 DOCUMENTATION / DATA / RECORDS MANAGEMENT

Data will be recorded promptly, legibly, and in indelible ink on the appropriate logbooks and forms. At the completion of a field effort, all logbooks, and field data forms shall be scanned and made electronically available to the project team. The original field forms, and logbook will be maintained in the project file.

#### 9.0 QUALITY CONTROL

There are several specific quality control issues pertinent to conducting water level and depth measurements at wells. These are:

- Where possible devices used to measure groundwater levels should be verified annually against a National Institute of Standards and Technology (NIST) traceable measuring tape. These devices should check to within 0.01 feet per 10 feet of length with an allowable error of 0.03 feet in the first 30 feet. Before each use, these devices should be prepared according to the manufacturer's instructions (if appropriate) and checked for obvious damage.
- All verification and maintenance data should be documented electronically or recorded in a logbook maintained at the EnSafe Project Office.
- These devices should be decontaminated according to the procedures specified in the SOP for Sampling and Field Equipment Decontamination prior to use at the next well.

 Hydrocarbons (light non-aqueous phase liquids) in water require special sensors for accurate water levels.

#### 10.0 NONCONFORMANCE AND CORRECTIVE ACTION

Deviations from the standard protocol, deviations from procedures specified in the Site Specific Work Plan, or any problems that occur during procedure implementation must be documented in the field logbook or on forms, and corrective action should be applied, if warranted. If alternative procedures are used, they must be approved by the Project Manager and be properly documented in the field logbook and/or on forms.

#### 11.0 REFERENCES

The following references provide other useful information.

#### 11.1 External References

- ASTM D 4750-87. 1988. Standard Test Method for Determining Subsurface Liquid Levels in a Borehole or Monitoring Well (Observation Well).
- United States Environmental Protection Agency. 1986. RCRA Groundwater Monitoring Technical Enforcement Document, OSWER-9950.1.
- United States Environmental Protection Agency. Science and Ecosystem Support Division. 2013. Operating Procedure. *Groundwater Level and Well Depth Measurement*. SESDPROC-105-R2. Athens Georgia.

# 11.2 EnSafe Associated Standard Operating Procedures

- EnSafe Standard Operating Procedure (SOP) for Sampling and Field Equipment Decontamination
- EnSafe Standard Operating Procedure for Logbooks
- Project Health and Safety Plan, Job Hazard Analysis, Safe Work Assessment Permit (SWAP)



# Standard Operating Procedure No. FS-03 Groundwater Sampling

These standards will ensure continuity within the organization.

#### **Preamble**

This Standard Operating Procedure (SOP) represents EnSafe's minimum standard of practice. State and federal requirements may vary, as may project-specific work plans, all of which must be consulted before work begins. This SOP may be modified to meet specific regulatory-, client-, or project-specific criteria.

#### 1.0 SCOPE AND APPLICABILITY

The procedures in this document are to be used by field personnel when collecting and handling groundwater samples in the field. Data obtained during groundwater sampling must be accurate, defensible, repeatable, and of the highest quality; therefore, it is critical that consistent and proper protocols are followed. This SOP is intended to ensure that collected groundwater samples will be representative of water in the aquifer or target formation and that the samples have not been altered or contaminated by the sampling or handling procedures.

On the occasion that field personnel determine that any of the procedures described are either inappropriate, inadequate, or impractical and that another procedure must be used to obtain a groundwater sample, the variant procedure will be documented in field logs, along with a description of the circumstances requiring its use. If used, alternative procedures must be approved by the project manager and be properly documented in the field logs.

The sampler must be aware of special equipment and precautions necessary when sampling groundwater for per- and polyfluoroalkyl substances (PFAS). SOP FS-12 **must** be used in conjunction with this SOP when sampling for PFAS and materials (e.g., Teflon) cited in this SOP (FS-03) **must** be substituted as directed in SOP FS-12.

#### 1.1 Definitions

*Chain-of-Custody* — A process used to maintain and document the chronological and custody history of a sample.

*PFAS* — A family of complex synthetic chemicals containing fluorine and carbon atoms, which make them extremely persistent in the environment. PFAS were developed to make various products such as non-stick cookware, stain and water repellants, cleaning products, food packaging, paints, and firefighting foam.

*Quality Assurance/Quality Control (QA/QC)* — The term QA/QC is often used to refer to the actions performed for ensuring the quality of a product, service, or process.

Shall or must — When these words are associated with a procedure or other item, the item is mandatory, and performance is expected in all cases. Deviations from a procedure containing these words shall be documented.



Should or may — When these words are used, the referenced item is recommended or suggested, but not mandatory.

Standard Operating Procedure — A document that gives a step-by-step description of how a specific operation, method, or procedure is performed.

*Volatile Organic Compound (VOC)* — Any organic compound that evaporates readily to the atmosphere.

# 1.2 Related Standard Operating Procedures

The following are related EnSafe SOPs:

- FC-01 Decontamination of Field Equipment
- FD-01 Field Documentation
- FQ-01 Quality Assurance/Quality Control Sampling
- FS-12 Per- and Polyfluoroalkyl Substances Field Sampling Protocol
- FT-02 Water Quality Parameter Testing

# 1.3 Health and Safety

Before commencing any groundwater sampling effort, field personnel shall review the health and safety requirements, any site-specific Health and Safety Plans, Job Safety Analysis, etc., to become familiar with the site hazards and safety requirements. Field personnel should make note of any known or potential hazards at the site, address chemicals that pose specific toxicity or safety concerns, and follow the relevant safety requirements.

Sampling activities may be performed by a single individual or with a group or team. Regardless of the number of individuals in a sampling team, each member of the team shall be comfortable with the tasks they are assigned. Comfort is loosely defined and includes not only items associated with the site-specific Health and Safety Plan or planning documents, but also a general awareness of the sample surroundings, including persons or wildlife in areas surrounding the site, quality of sample area (e.g., abandoned/vacant buildings, building condition, ground surface, heights, possible confined spaces), and weather conditions (e.g., extreme heat or cold and unexpected changes in weather). Wells that have not been sampled regularly may harbor ants, spiders, or wasps so caution should always be exercised when opening wells. If any individual is, or becomes, uncomfortable with the required sampling activities, then the sampling activities shall be reassessed.

Safety glasses with splash shields or goggles, disposable gloves, and steel-toe boots shall be worn during all groundwater sampling events, unless the site-specific Health and Safety Plan designates otherwise.

#### 1.4 Cautions

The following precautions should be considered when collecting groundwater samples.

 Employees should be trained on the correct operation of sampling equipment and the correct operation and calibration of test equipment before proceeding with sampling. Improper use of sampling or test equipment could result in equipment damage or compromised sampling results.



- Know the well characteristics (i.e., well depth, depth to groundwater, volume of water to be evacuated) before sampling so that the appropriate pump and tubing is selected.
- Ensure the sample equipment is compatible (i.e., non-reactive, does not sorb or leach) with the analytes of concern.
- Special care to prevent sample contamination includes storing samples in a secure location to preclude conditions that could alter the sample properties. Samples shall be secured using custody seals during long-term storage or shipment.
- To minimize the potential for cross-contamination, always sample from the least contaminated location to the most contaminated location.
- Collected samples must remain in the custody of the sampler or sample custodian until the samples are relinquished to another party.
- If samples are transported by the sampler, they will remain under his/her custody or be secured until they are relinquished.
- Chain-of-custody documents shall be filled out and remain with the samples until custody is relinquished.
- Field sampling will be documented in field logs, which may be in the form of a logbook, field forms, or electronically. PFAS sampling will adhere to the material exceptions cited in SOP FS-12.

#### 1.5 Interferences

Sampling methods and procedures shall not interfere with sample quality. The exact methods for sampling should be selected carefully depending on the depth of groundwater and construction of monitoring wells.

#### 1.6 Personnel Qualifications

Personnel conducting groundwater sampling must be knowledgeable of the procedures in this SOP and related EnSafe SOPs. Training for each procedure will depend on the specific procedure. Field personnel are responsible for conducting groundwater sampling procedures according to this SOP and site-specific planning documents.

#### 2.0 APPARATUS AND MATERIALS

Field personnel shall consult site-specific planning documents to determine the equipment requirements for the sampling procedures to be followed during the sampling effort. The specific apparatus and materials required will depend on the samples being collected.

The following equipment and materials may be needed to conduct the sampling procedures outlined in this SOP.



# **Purging and Sampling Equipment**

- Pump (peristaltic, portable bladder, submersible)
- Polyethylene or Teflon bladders (for portable bladder pumps)
- Bladder pump controller (for portable bladder pumps)
- Air compressor (for portable bladder pumps)
- Nitrogen cylinders (for portable bladder pumps)
- 12-volt power source
- Polyethylene inlet and discharge tubing
- Silicone tubing appropriate for peristaltic pump head
- Teflon bailer appropriately sized for well
- Disposable bailer string (polypropylene)
- Multi-parameter water quality meter(s) with flow-through cell to measure temperature, pH, conductivity, dissolved oxygen (DO), and oxidation reduction potential (ORP)
- Turbidity meter
- Water level meter
- Oil/water interface probe

# **General Equipment**

- Laboratory-supplied sampling containers
- Sample labels
- 5-gallon buckets
- Instrument calibration solutions
- Stopwatch or watch
- Disposable nitrile gloves
- Plastic zipper lock storage bags

Not all listed equipment may be necessary for a specific activity. Additional equipment may be required, depending on field conditions, requirements of the site-specific planning documents, or other planned sampling activities.

#### 3.0 GROUNDWATER SAMPLING PROCEDURES

The following groundwater sampling procedures are based on currently accepted techniques. The specific sampling protocols to be followed at a site may vary from what is specified herein based on the requirements of a state environmental agency, the U.S. Environmental Protection Agency, client need/request, or site conditions and limitations. The site-specific planning documents should contain specific information on the sampling techniques, equipment, and protocols to be followed during sampling.

# 3.1 Special Sampling Considerations Volatile Organic Compounds Analysis

Groundwater samples for VOC analysis must be collected in 40-milliliter (mL) glass vials with Teflon septa. The vial may either be pre-preserved with concentrated hydrochloric acid or unpreserved. Preserved samples have a 14-day holding time whereas unpreserved samples have a 7-day holding time. In most cases, the preserved vials are used to take advantage of the extended holding time. In some situations, however, it may be necessary to use the unpreserved vials. For example, if the groundwater has considerable dissolved limestone (i.e., is highly calcareous), there will likely be an effervescent reaction between the hydrochloric acid and the water that produces an abundance of fine bubbles and renders the sample unacceptable. In that case, unpreserved vials should be used.



If unpreserved vials are not available, the acid can be removed from the vial by flushing with the groundwater that is being sampled several times. The chain-of-custody form must reflect that the sample is unpreserved, and the laboratory should be notified via email, text, or phone to inform them to expect unpreserved samples with shorter holding times.

The samples should be collected with as little agitation or disturbance as possible. The vial should be filled so that there is a meniscus at the top of the vial and no bubbles or headspace should be present in the vial after it is capped. After the cap is securely tightened, the vial should be inverted and tapped on the palm or knuckle to check if any bubbles are dislodged. If a bubble or bubbles are present, the vial should be topped off using a minimal amount of sample to re-establish the meniscus during which care should be taken not to flush any preservative out of the vial. If bubbles are still present after topping off and capping the vial, a new vial should be obtained, and the sample recollected. While the laboratory preparation method allows for bubbles up to 6 millimeters at the time of analysis, dissolved or entrained gases can coalesce during shipment. Collecting VOC vials absent of bubbles is generally feasible and a reasonable precaution.

# **Trace Contaminant Groundwater Sampling**

- Sampling equipment must be constructed of Teflon or stainless-steel materials. Bailers and pumps should be of Teflon and stainless-steel construction throughout.
- New Teflon tubing should be used at each well, although tubing dedicated to a specific well
  may be reused, either after decontamination or storage in the well between sampling events.
- A clean pair of new non-powdered disposable gloves will be worn each time a different location is sampled, and the gloves should be donned immediately prior to sampling. The gloves should not contact the media being sampled and should be changed any time during sample collection if their cleanliness is compromised.
- Upon collection, individual sample containers (along with bubble wrap, if necessary) shall be placed in clean, disposable zipper-lock closure plastic bags for storage and/or shipment.
- Containers of samples suspected of containing high concentrations of contaminants shall be stored separately.
- Sampling should proceed from the least suspected contaminated area to the most suspected contaminated area if purging and sampling equipment are to be reused. Waste or highly contaminated samples must not be placed in the same cooler as samples (e.g., environmental or background) expected to contain lower contaminant levels.
- If possible, one member of the field sampling team should take all notes, collect photographs, and fill out labels, etc., while other members collect the samples.
- Clean plastic sheeting will be placed on the ground at each sample location to prevent or minimize contaminating sampling equipment by accidental contact with the ground surface.
- Samplers must use new, clean disposable, or non-disposable equipment cleaned according to procedures contained in Field Decontamination SOP FC-01.



# 3.2 Overview of Purging and Sampling Strategies

Purging is the process of removing stagnant water from a well, immediately before sampling, causing its replacement by groundwater from the adjacent formation that is representative of aquifer conditions. Sampling is the process of obtaining, containerizing, and preserving (when required) a groundwater sample after the purging process is complete. There are several approaches to well purging and sampling that may be appropriate in various circumstances or when using various combinations of available equipment. They are briefly summarized below and in Table 1 (Purge and Sample Strategies with Equipment Considerations).

The Multi-Volume Purge method involves removing a minimum of three well volumes of water from the top of the water column and then sampling when the well has achieved water quality parameter stability and adequately low turbidity. This is a traditional method and consistent results are generally obtainable by a variety of skilled personnel. A drawback is that large volumes of purge water may be produced for large diameter or deep wells.

The Low-Flow method involves purging the well at a relatively low flow rate that minimizes drawdown, with the pump or tubing inlet located within the screened interval of the well. The well is sampled when water quality parameters are stable, adequately low turbidity is achieved, and the water level has achieved a stable drawdown (an unchanging water level). This method is often faster than Multi-Volume Purge and generates less purge water, but the method requires more skill and judgment on the part of sampling personnel.

The Multi-Volume Purge and Low-Flow methods can be considered equivalent for conventionally screened and filter-packed wells in that they both sample a flow-weighted average of water entering the well during pumping. However, other variables can result in differences between results with the two methods. In repeat sampling events, the purging method should not change without appropriate cause and the change should be noted in the field logs.

Minimum-Purge and No-Purge methods assume that water within the screened interval of the well is at equilibrium with the water in the surrounding aquifer. This assumption should be carefully considered before using either of these methods and various cautions are discussed in sections below. The Minimum-Purge and No-Purge methods are most useful for long-term monitoring and are generally inappropriate for the early stages of investigation. In some cases, the methods might be used to gather screening-level data from wells that are too large to practically purge or have other sampling complications.

The Minimum-Purge and No-Purge methods collect water in the vicinity of the device under near-static conditions and are not equivalent to the Multi-Volume Purge and Low-Flow methods. Stratification of horizontal flow or vertical flow conditions within the well can result in non-intuitive and deceptive results. A comparison study should be conducted before transitioning a sampling program to the Minimum-Purge or No-Purge methods.

#### 3.3 Purging

Wells are purged to eliminate stagnant water residing in the casing and/or screen that has undergone geochemical changes or loss of VOCs. At the conclusion of purging, the desired flow-weighted average of water entering the well under pumping conditions will be available for sampling. Turbidity is often elevated during purging by the disturbance of formation materials at the borehole walls.



Table 1
Purge and Sample Strategies with Equipment Considerations

Purging Strategy	Purge Eqpt	Sample Eqpt	Comments				
Multi-Volume Purge			Overall Method Comments- Advantages: Consistent results can be achieved with minimal skill level required. Common, simple equipment can be used. Disadvantages: Can result in large volumes of purge water. Can take extended periods of time with large diameter wells or long water columns.				
la this tenditional marked 2.5 well values of water	Bailer	Bailer	Bailers are rarely used for purging due to the effort required, the difficulty of lowering turbidity adequately, and the possibility of aerating the upper water column.				
In this traditional method, 3-5 well volumes of water are removed from the top of the water column while verifying the stability of water quality parameters.	Electric Submersible Pump	Bailer	Common multiple-volume setup when depth to water exceeds 25 feet. Abbreviated pump decontamination procedure can be used between wells.				
Following the well purge, the well is sampled from the top of the water column.	Electric Submersible Pump	Electric Submersible Pump	Requires full pump decontamination and new tubing at each well. In most cases the pump would be deployed to the screened interval instead to perform Low-Flow sampling.				
top of the water column.	Peristaltic Pump	Peristaltic Pump	Common, multi-volume setup when depth to water is less than 25 feet. Special sampling techniques are required for the collection of SVOCs and VOCs.				
Low-Flow methods			Overall Method Comments- Advantages: Lower volumes of purge water. May be faster, especially with longer water columns. Disadvantages: Requires greater skill for consistent results. Higher tubing costs than multi-volume method.				
	Electric Submersible Pump	Electric Submersible Pump	Commonly used when depth to water exceeds 25 feet. Pump is cleaned to sample equipment standards prior to sampling each well and new or dedicated tubing used for each well. Concerns have been raised concerning VOC loss from agitation in the turbine section or from sample heating.				
The pump or tubing inlet is placed within the screened interval and the well is purged to stable water quality parameters while maintaining stable drawdown of the	Peristaltic Pump	Peristaltic Pump	Commonly used where depth to water is less than 25 feet. Special sampling techniques required for the collection of SVOCs and VOCs. Concerns have been raised concerning VOC loss from vacuum created in sample tubing.				
water level.	Bladder Pump	Bladder Pump	Least danger of VOC loss as entire sample train is under positive pressure and little sample heating occurs. Difficult to remove large volumes of water in reasonable time. Mild surging effect may keep turbidity elevated in sensitive wells.				
Minimum-Purge, No-Purge Methods			Overall Method Comments- Advantages: Very little or no waste water. Well suited to repeat sampling events. Likely faster with lower costs. Disadvantages: Not directly equivalent to other methods. Vertical stratification or vertical flow conditions in the screened interval can result in deceptive or non-intuitive analytical results.				
	Pumps, various	Pumps, various	In the minimum-purge method, the internal volume of the sample tubing and pump is calculated. One volume of the pump and tubing is purged to flush the equipment and the well is then sampled.				
Predicated on the assumption that aquifer flow through the well maintains the water in the screened interval in a state equivalent to that in the aquifer. This assumption should be proven or the data qualified. Sampling is conducted with little or no purge, or by	na	Passive Diffusion Bags	In most common form, a sealed water-filled polyethylene bag is allowed to equilibrate in the water column. Suitable primarily for VOCs. Generally require 2 week minimum in-situ residence time.				
	na	Hydrasleeves	Collect a fixed volume of water from a specific interval. Requires duplicate samplers or redeployment for larger volumes. Sorbtion issues may bias results.				
equilibrating a sampler in screened interval.	na	Snap sampler	Deploys a sample container in the sampling interval where it is allowed to equilibrate (commonly for two weeks) before being sealed insitu by the sampler mechanism and retrieved. Limited to specific containers.				



As many contaminants (metals and organics) will sorb to the formation particles, a groundwater sample that includes particles will not represent the dissolved concentrations of the contaminants. Thus, a secondary goal of purging is to reduce the turbidity to the point that the sample will represent the dissolved concentration of contaminants.

In order to determine when a well has been adequately purged, sampling personnel should monitor, at a minimum, the pH, conductivity, DO, and turbidity of the groundwater removed, and the volume of water removed during purging. The following measurements should be recorded on the groundwater sampling form (see Attachment A) or in the field logbook: the start time of purging, the parameter measurements at intervals during purging, estimated pumped volumes, depths to water for Low-Flow purging, and any notes of unusual conditions. A typical table used for Low-Flow purging is reproduced below.

Circle one: DEVELO	PMENT	SAM	PLING			☐ Balle	r Pump
Time (hh:mm):	1605	1610	1615	1620	1625		
pH (units):	5.20	4.98	4.94	4,94	5.01		
Conductivity (mS/cm):	0,091	0.094	0.093	0.092	0.091		
Turbidity (NTU):	427	2.51	1.103	1.74	1.28		
DO (mg/L): Horiba	/	/		/			
YSI	6.10	6127	6,39	6.45	4.38		
Temperature (C°):	17.36	17.47	16.39	16195	16.51	1	
ORP (mV):	117.0	127.7	139.3	143.6	138.6		
Volume Purged (gal):	011	0.5	175	0.8	1.0		11
Depth to Water (ft):	93.02	93.02	93.02	93,02	93.02		

#### 3.4 Parameter Stabilization Criteria

With respect to the groundwater chemistry, an adequate purge is achieved when the pH and conductivity of groundwater have stabilized, and the turbidity has either stabilized or is below 20 Nephelometric Turbidity Units (NTUs).

Stabilization occurs when, for at least three consecutive measurements, the pH remains constant within 0.2 Standard Unit and conductivity varies no more than 5%. Other parameters, such as DO or ORP, may also be used as a purge adequacy parameter. Normal stability goals for DO are 0.2 mg/L or 10% change in saturation, whichever is greater; the common range for DO in groundwater is 0.0 to 3.0 mg/L. DO and ORP measurements must be conducted using either a flow-through cell or an over-topping cell to minimize oxygenation of the sample during measurement. A reasonable ORP stability goal is a range of 20 millivolts (mV) although ORP is rarely at equilibrium in environmental media and often will not demonstrate enough stability to be used as a purge stabilization parameter. A negative value indicates an anaerobic environment or reducing condition. For this reason, negative ORP readings should be associated with DO readings of less than 0.5 mg/L; with negative ORP readings, the water may exhibit a sulfur odor or gray color. Positive ORP readings should be associated with DO readings greater than 0.5 mg/L and lack of sulfur odors.

Determining the frequency of measurements has generally been left to Best Professional Judgement. Care is in order, as measurements recorded at frequent intervals with low flow rates can falsely indicate stability of parameters. Several measurements should be made early in the well purge to establish the direction and magnitude of trends, which can then inform the stability decision. Stability



parameters should either be not trending, or approaching an asymptote, when a stability determination is made. As a matter of practice, parameter measurements are generally made at 5-to 10-minute intervals.

Because the measured groundwater temperature during purging is subject to changes related to surface ambient conditions and pumping rates, its usefulness is limited for the purpose of determining parameter stability. Even though temperature is not used to determine stability, it is still advisable to record the temperature of purge water as it is often used in the interpretation of other parameters.

Most monitoring instruments require at least daily calibration in the field and shall be performed in accordance with the manufacturer's specifications. Special considerations and calibration related to water quality instruments are provided in SOP FT-02 Water Quality Parameter Testing.

## 3.5 Multi-Volume Purge

In the traditional Multi-Volume Purge method, water is removed from the top of the water column, causing water to enter the screen and flush stagnant casing water upward to be subsequently removed. When mixing fresh and stagnant water in the casing section, a minimum of three well volumes is removed, at which time purging can be terminated upon parameter stabilization. Wells can be assumed to be adequately purged when five well volumes have been removed, although further purging may be conducted to meet specific goals, such as further reduction of turbidity.

## 3.5.1 Purge Volume Determination

Prior to initiating the purge, the amount of water standing in the water column (water inside the well riser and screen) should be determined by measuring the diameter of the well, the water level, and the total depth of the well prior to inserting a pump or tubing into the well. The water level is subtracted from the total well depth, providing the length of the water column. Once this information is obtained, the volume of water to be purged can be determined using several methods, one of which is using the following equation:

$$V = 0.041 d^2h$$

Where:

h = length of water column in feet

d = diameter of well in inches

V = one well volume in gallons

The field notes should reflect the single well volume calculations or determinations and a reference to the appropriate multiplication of that volume (i.e., a minimum three well volumes) clearly identified as an initial purge volume goal.

#### 3.5.2 Pumping Conditions

The pump or tubing inlet should be located at the top of the water column. If the pump is placed deep into the water column, the water above the pump may not be removed and the subsequent samples, particularly if collected with a bailer, may not be representative of the aquifer conditions. If the recovery rate of the well is faster than the pump rate and no observable drawdown occurs, the pump should be raised until the intake is as close as possible to the top of the water column for the duration of purging. If the pump rate exceeds the recovery rate of the well, the pump or tubing will have to be lowered to accommodate the drawdown.



# 3.5.3 Stability of Chemical Parameters

In the Multi-Volume Purge method, a stability determination may be made after three well volumes have been removed. If the chemical parameters have not stabilized according to the above criteria, additional (up to a total of five) well volumes should be removed. If the parameters have not stabilized after the removal of five well volumes, it is at the discretion of the project manager whether or not to collect a sample or to continue purging. If, after five well volumes, pH, DO and conductivity have stabilized but the turbidity is decreasing and approaching an acceptable level, additional purging should be considered to obtain the best sample possible.

# 3.5.4 Sample Collection

There are several means by which sampling can proceed after adequate volume has been purged and water quality parameters have stabilized. If a submersible pump and tubing are of suitable material and cleanliness for sample collection, sampling can proceed immediately by directly filling bottles from the tubing outlet. With the Multi-Volume Purge method, the pump is commonly set up and cleaned in a manner suitable only for purging. In these cases, the pump is stopped and removed from the well and sampling proceeds with a bailer per the procedure described in Section 3.8.3. The pump should have a check valve to prevent water in the pump tubing from discharging back into the well when the pump is stopped. If a peristaltic pump is used, sampling can proceed as described in Section 3.8.1.

#### 3.6 Low-Flow Method

This method involves placing the pump or tubing inlet within the screened interval of the well and purging at a low enough rate to achieve stable drawdown and minimal depression of the water level. The well is sampled without interruption after field parameters are stable and low turbidity is achieved. In general, only water in the screened interval of the well is pumped and the stagnant water in the well casing above the screen is not removed. Wells can generally be sampled in less time with less purge volume than with the Multi-Volume Purge method. More attention is required in the assessment of stability criteria than the Multi-Volume Purge method.

Low-flow purging does not require calculation of the water volume in the well, since purging is based solely on indicator parameter stabilization. Instead, the volume of the pump and discharge tubing are used to determine field measurement frequency and/or the minimum purge volume. Pump chamber or bladder volumes can be obtained from the manufacturer. Volumes of the sample tubing can be calculated or taken from Table 2.

Well casing volumes should still be calculated and recorded on the field logs in the event parameter stabilization is not achieved after a three-casing-volume purge.

Table 2						
Equipment Volumes for Variable Tube Diameters						
Discharge Tubing Volumes						
Tubing Diameter (inches) Volume per foot						
1/2 OD and 3/8 ID	20 milliliter					
3/8 OD and 1/4 ID	10 milliliter					
1/4 OD and 1/8 ID	5 milliliter					

Notes:

OD = outer diameter
ID = inner diameter



# 3.6.1 Placement of Pump Tubing or Intake

The inlet of the pump tubing or intake of the submersible pump is placed in the approximate midportion of the screened interval of the well. While it is often thought that particular aquifer zones can be targeted by specific pump or intake placement, for conventionally constructed screened and filter-packed monitoring wells, the zone monitored is only weakly dependent on the intake placement.<sup>1</sup>

The pump (or tubing) can be placed by carefully lowering it to the bottom of the well and then withdrawing half of the screen length, plus the length of any sump sections at the bottom of the well. A drawback of this approach is that it may stir up sediment at the well bottom. An alternate approach is to lower the pump or tubing a measured distance to place it at mid-screen without touching the bottom of the well. In the case of pumps, special care should be used by lowering it slowly, especially in the screened interval, to prevent elevating turbidity needlessly by the surging action of the pump.

# 3.6.2 Conditions of Pumping

Prior to initiating pumping, a properly decontaminated water level indicator should be lowered into the well to measure the water level prior to and during the purging process. Ideally, there should be only a slight and stable drawdown of the water column after pumping begins. In some cases, it will be necessary for the well to draw down a considerable distance (10 feet or more in extreme cases) to maintain a minimal usable pumping rate for sampling (100-200 mL per minute). Excessive pump rates and drawdown can result in increased turbidity or aeration of the sample if the screen is exposed. Stable drawdown is an essential condition of the Low-Flow method. If the stable drawdown condition cannot be met, then one of the other methods should be employed.

# 3.6.3 Stability of Chemical Parameters

As with the Multi-Volume Purging method described, it is important that all chemical parameters be stable prior to sampling. It is common for wells to require removal of one or more screened-interval volumes (approximately 2 gallons for a 10-foot screen in a 2-inch diameter well) to achieve stability. Although it is possible for wells to achieve stability with lower purge volumes, sampling personnel should exercise caution in making an premature stability determination.

# 3.6.4 Sample Collection

Low-Flow sampling is implemented using a pump and tubing suitable for sampling. After making the determination of parameter stability with stable drawdown, sampling can proceed immediately. When submersible or bladder pumps are used, sampling can proceed by directly filling bottles from the tubing outlet. When peristaltic pumps are used, sampling can proceed per the procedure described in Section 3.8.1.

# 3.7 Minimum-Purge and No-Purge Sampling

The Minimum-Purge and No-Purge sampling methods are employed when it is necessary to keep purge volumes to an absolute minimum, it is desirable to reduce long-term monitoring costs, or large wells or other limitations prevent well purging. The underlying assumption when employing these methods is that the water within the well screen is equilibrated with the groundwater in the associated formation. This assumption should be demonstrated prior to using these methods or the results suitably qualified. These methods are generally impractical to implement because of the lack of

<sup>&</sup>lt;sup>1</sup> Varljen, M., Barcelona, M., Obereiner, J., & Kaminski, D. (2006). Numerical simulations to assess the monitoring zone achieved during Low-Flow purging and sampling. Ground Water Monitoring and Remediation, 26(1), 44-52.



hydrogeological information in early investigative phases and the necessity with some methods that the samplers be pre-deployed to allow equilibration.

Vertical flow conditions and stratification of the water column have also been known to result in deceptive and non-intuitive analytical results. The use of these methods in the early phases of investigation can result in misinterpretation of site conditions and plume boundaries.

Particular caution is in order in using these methods when any of the following conditions exist:

- Low hydraulic conductivity (<10<sup>-5</sup> centimeter/second)
- Low groundwater surface gradients
- Fractured bedrock
- Wells with long screened intervals
- Wells screened in materials of varying hydraulic conductivities

If it is desired to transition a long-term monitoring program to Minimum-Purge or No-Purge sampling, a pilot study should be conducted where the Minimum-Purge or No-Purge sample results are compared to the conventional methods in use. Multiple samplers may be deployed in the screened interval to help establish appropriate monitoring intervals.

These methods are in common use and for the purposes of the quality system they can be considered standard, but unaccredited, procedures. Several Minimum-Purge or No-Purge procedures that might be employed are shown below. It is not the intention to recommend particular equipment or vendors, and other equipment that can accomplish the same goals may be suitable.

# 3.7.1 Minimum-Purge Sampling

The pump or tubing inlet is deployed in the screened interval. A volume of water equal to the internal pump and tubing volume is pumped to flush the equipment. Sampling then proceeds immediately. While superficially similar to Low-Flow sampling, the results obtained using this method will be sensitive to the vertical pump or tubing inlet placement and are subject to the limitations described in Section 3.7.

# 3.7.2 Passive Diffusion Bags

The No-Purge Passive Diffusion Bag (PDB) typically consists of a sealed low-density polyethylene (LDPE) bag containing deionized water. The bag is deployed in the screened interval of a well and allowed to equilibrate, commonly for two weeks, prior to retrieval and decanting of the water into sample containers. Many VOCs will reach equilibrium across the LDPE material, including petroleum compounds and chlorinated solvents. Compounds showing poor equilibration across LDPE include acetone, methyl tertiary butyl ether, methyl isobutyl ketone, and styrene. PDBs have been constructed of other materials for sampling other analytes, but the vast majority of PDB samplers are of the LDPE material. For more information regarding PDB sampling and available vendors that sell PDBs, see SOP Diffusion Sampling FS-05.

#### 3.7.3 HydraSleeves

HydraSleeves are No-Purge grab sampling devices consisting of a closed-bottom sleeve of low-density polyethylene with a reed valve at the top. They are deployed in a collapsed state to the desired interval and fill themselves through the reed valve when pulled upward through the sampling interval. The following is a summary of their operation.



- Sampler placement A reusable weight is attached to the bottom of the sampler or the sampler is clipped to a weighted line. The HydraSleeve is lowered on the weighted line and placed with the top of the sampler at the bottom of the desired sampling interval. In-situ water pressure keeps the reed valve closed, preventing water from entering the sampler. The well is allowed to return to equilibrium.
- Sample collection The reed valve opens to allow filling when the sampler is moved upward
  faster than 1 foot per second, either in one continuous upward pull or by cycling the sampler
  up and down to sample a shorter interval. There is no change in water level and only minimal
  agitation during collection.
- Sample retrieval When the flexible sleeve is full, the reed valve closes, and the sampler can
  be recovered without entry of extraneous overlying fluids. Samples are removed by
  puncturing the sleeve with the pointed discharge tube and draining the contents into
  containers for sampling or field parameter measurements. Because the HydraSleeve is
  retrieved before equilibration can occur and is constructed of non-Teflon materials, there may
  be issues with sorption of contaminants when using this sampler.

# 3.7.4 Snap Samplers

The Snap Sampler is a patented No-Purge groundwater sampling device that employs a double-end-opening bottle with Snap-sealing end caps. The dedicated device is deployed at the desired position in the screened interval with up to six Snap Samplers and six individual sampling bottles. The device is allowed to equilibrate in the screened interval and retrieved between 3 and 14 days after deployment. Longer deployment times are possible to accommodate sampling schedules.

To operate, Snap Samplers are loaded with Snap Sampler bottles and the Snap caps are set in an open position. Samplers are deployed downhole with an attachment/trigger line and left to equilibrate. To collect samples, the Snap Sampler bottles seal under the water surface by pulling a mechanical trigger line or using an electric or pneumatic trigger system. The trigger releases Teflon Snap Caps that seal the double-ended bottles. The end caps are designed to seal the water sample within the bottles with no headspace vapor. After the closed vial is retrieved from the well, the bottles are prepared with standard septa screw caps and labeled for laboratory submittal. The manufacturer of the Snap Sampler provides considerable information on the validation and use of the device.

## 3.8 Equipment Considerations

Equipment choices are dictated by the purging and sampling method used, the depth to water, the quantity of water to be pumped, and quality considerations. The advantages and disadvantages of various commonly used pumps are discussed in the sections below and summarized in Table 1 (Purge and Sample Strategies with Equipment Considerations).

#### 3.8.1 Use of Peristaltic Pumps

Peristaltic pumps are simple, inexpensive, and reliable equipment for purging and sampling where the limit of suction is not exceeded (approximately 25-30 vertical feet from the groundwater surface to the pump). When used for sampling, they should be equipped with new Teflon, or dedicated, tubing for each well. The flexible peristaltic pump-head tubing should also be changed between wells.



Samples for organic analyses generally should not be exposed to the flexible peristaltic pump-head tubing unless permitted in state-specific SOPs (e.g., Florida) due to the risk that the tubing would sorb contaminants and the propensity for this tubing to contribute organic compounds to the sample. Samples can be collected without contact with the pump-head tubing by using vacuum transfer caps for analyses requiring 1- to 4-liter glass containers/transfer bottles and the use of the soda-straw method for filling VOC vials.

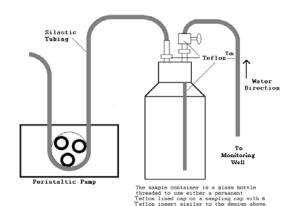
The sample containers for more turbidity-sensitive analyses are filled first, as filling the VOC vials and, to a lesser extent, the glass bottles may disturb the well and increase turbidity. The most appropriate order of sampling with a peristaltic pump is to fill VOCs, semi-volatile organic compounds, pesticides, polychlorinated biphenyls, metals, cyanide, and wet chemistry parameters (chloride, sulfate, nitrate, nitrite, etc.).

The following step-by-step procedure assumes that the pump has been set up and that containers for a typical full suite of analyses will be filled. The procedure is suitable for use with Multi-Volume Purge and Low-Flow purge methods with minor differences in the collection of VOCs.

- Deploy the lower end of the tubing to the desired point in the well (i.e., top-of-water for the Multi-Volume Purge method or the mid-screen for the Low-Flow method). Connect the well tubing to the flexible pump-head tubing and connect a short piece of tubing from the pumphead tubing to a measuring bucket.
- 2. Turn on the pump and establish a suitable pumping rate. For the Multi-Volume Purge method, the rate will generally be sufficiently fast enough that the well can sustain without elevating turbidity. For the Low-Flow method, the pump rate is established at a slower rate to maintain a minimal and stable drawdown level.
- 3. Proceed with the measurement of water quality parameters and adjust the pump rate as needed to achieve low turbidity and stable drawdown.
- 4. When the well has been sufficiently purged, fill directly from the pump outlet containers for metals and any other contaminants except semi-volatile organic compounds. There is no

need to interrupt pumping. The tubing should be held at the opening of the container and should not touch the container during filling. Protect caps from dust and debris during filling.

- 5. After filling the containers, stop the pump. Make sure that the tubing leading into the well is secured against movement during the following operations.
- 6. Create a crimp in the well tubing approximately 1 foot from the pump and grasp the crimped tubing in one hand. It is generally most effective to create a "double Z" crimp.





- 7. Cut the sample tubing between the crimp and the pump. The tightly held crimped tubing should keep water from running back into the well. In lieu of cutting the tubing, the well tubing can be disconnected from the pump and a short piece of tubing connected in its place.
- 8. Insert both free ends of the tubing into the ferrule-nut fittings of a pre-cleaned Teflon transfer cap assembly and tighten the nuts. Attach the transfer cap assembly to the first glass container for semi-volatile organic compound analysis and securely tighten the threaded ring.
- 9. Turn the pump on. Very slowly release the Z crimp in the sample tubing. As vacuum builds up in the sample container, water should begin to move up the sample tubing instead of back into the well. If after several minutes water has not moved up the tubing, check the tightness of fittings and the attachment of the cap to the bottle. Allowing water to rush back down the tubing from the Z crimp can surge the well and elevate turbidity.
- 10. Fill the container to about halfway between the shoulder and the neck. Crimp the well tubing. Move the transfer cap to any additional bottles and repeat the filling process.
- 11. When finished filling bottles with the transfer cap, again crimp the tubing. Remove the well tubing from the transfer cap and reattach it to the pump. Slowly run the pump and release the crimp until water is approaching the flexible peristaltic tubing.
- 12. Make a kink or otherwise mark the tubing at the top of the casing in case the tubing needs to be reinserted for additional sample volume. Slowly remove the tubing from the well and coil it in one hand in loose coils. With the top end of the tubing blocked, water is retained in the tubing as it is withdrawn, much as in a capped soda straw, hence the name for this method.
- 13. Remove the top from a 40-ml VOC vial and position the end of the sample tubing near the top of the vial. Reverse the pump direction and turn the speed knob to its slowest position. Turn on the pump and slowly increase speed until water slowly fills the vial. Fill the vial with a slow constant flow that does not agitate the water in the vial or entrain bubbles. Continue to fill the vial until a convex meniscus forms on the top of the vial and turn off the pump.
- 14. Carefully screw the septum-lid to the vial and fasten firmly. Invert the vial and tap on your knuckles to check for bubbles. Carefully add additional volume to the vial if necessary. Small bubbles are undesirable but may be unavoidable with some media, especially when using prepreserved vials.
- 15. Repeat the filling process for additional vials. Avoid partially filling vials; if more volume is required than that contained in the tubing, purge the remaining water from the tubing and reinsert the tubing in the well to the level marked previously. Run the pump to refill the tubing. If performing Low-Flow sampling, run additional volume through the pump to purge any water that may have been collected from the stagnant water column.
- 16. Fill additional vials as needed. Be sure that any water that has contacted the flexible peristaltic tubing is not pumped into a vial.



# 3.8.2 Use of Submersible Centrifugal Pumps

Submersible centrifugal pumps are used in 2-inch diameter and larger wells. They are especially useful where large volumes of water are to be removed or when the groundwater surface is a large distance below ground surface. Commonly used pumps are the Grundfos Redi-Flo2, the Geotech GeoSub, and various Monsoon-style pumps. Other pumps are acceptable if constructed of suitable materials.

When used with the Multi-Volume Purge method, the pump is generally used only to purge, and sampling is performed using a bailer. In this use, the pump can be used with polyethylene or other tubing or hose that will not contribute contaminants to the well. The pump and tubing are decontaminated between wells per the relevant provisions of SOP Field Decontamination FC-01. When used in this application, the pump should be equipped with a check valve to prevent water in the discharge tubing or hose from running back down into the well.

When used for Low-Flow purging and sampling, the pump must be constructed of stainless-steel and Teflon. Pump cleaning at each well follows the more stringent procedures described in SOP Field Decontamination FC-01 for this application. The sample tubing should be either new Teflon tubing or tubing dedicated to each well. Dedicated tubing would ideally be cleaned between uses but tubing stored in the well casing between uses is acceptable, although caution should be exercised where very high concentrations of contaminants have been sampled in a well.

#### 3.8.3 Use of Bailers

Bailers are a common means of sampling when the Multi-Volume Purge method is used. They are occasionally used for purging when other equipment is not available or has failed. As bailers surge the well on each withdrawal, it is difficult to lower turbidity adequately during a well purge. When used for sampling, bailers can elevate turbidity in a well before all sample volume is collected. If not lowered carefully into the top of the water column, the agitation may strip volatile compounds. Due to the difficulties and limitations inherent in their use, other sampling or purging means should generally be given preference over bailers.

Bailers should be closed-top Teflon bailers with Teflon-coated stainless-steel leaders used with new nylon haul rope. They are lowered gently into the top of the water column, allowed to fill, and removed slowly. It is critical that bailers be slowly and gently immersed into the top of the water column, particularly during final stages of purging and during sampling, to minimize turbidity and loss of volatile compounds.

If the well has previously been purged with a pump, there is likely stagnant water at the top of the well that was above the pump or tubing inlet. Several bailers of water should be retrieved and discarded to assure the upper stagnant water has been removed.

When sampling, containers are filled directly by pouring from the outlet at the top of the bailer. Containers for metals analysis should be filled first in case the bailing process increases well turbidity. VOC vials should be filled carefully and slowly with a constant flow to reduce agitation and stripping VOCs.

# 3.8.4 Use of Bladder Pumps

Bladder pumps use a source of compressed gas (i.e., commercial nitrogen in a tank or air compressor) to compress and release a bladder straddled by check valves within the pump body. As the bladder



is compressed, water is expelled out the upper check valve to the surface. When gas pressure is released, the bladder refills as well water enters the lower pump inlet. A control unit is used to control the pressure and timing of the bladder inflation gas flow.

Bladder pumps are capable of pumping groundwater from moderate depths (50-100 feet) but are not capable of high flow rates. As they operate cyclically, the well is surged slightly on each cycle and it may be difficult to lower turbidity in sensitive or poorly developed wells. As the entire sample train is under positive pressure and the pumps develop little heat, they are ideal for collecting samples for VOC analysis.

Prior to sampling and between each well the pumps shall be cleaned internally and externally per the provisions of SOP Field Decontamination FC-01 and a new Teflon bladder shall be installed. New (or dedicated) Teflon sample tubing will be used at each well. Polyethylene tubing is typically used for the compressed gas drive line and should also be new or dedicated tubing.

# 3.8.5 Use of Inertial Pumps

Inertial pumps consist of a check valve that is affixed to the lower end of semi-rigid tubing. The tubing and valve are cycled up and down, allowing water to alternately be drawn into the check valve inlet, then pulled up towards the surface. Two commonly used inertial pumps are the Waterra pump (for well diameters larger than 1 inch) and the Geoprobe Tubing Check Valve (for smaller-diameter wells). The primary use of these pumps is in well development where their near immunity to silt is an advantage. Inertial pumps should not be used for the final well purge or for sampling as there is a low likelihood of reducing turbidity to appropriate levels and they have the potential to strip volatiles from the water column through agitation.

To set up the pump, screw the check valve onto the discharge tubing where it will cut its own threads. In the case of the Waterra pump, a surge block can also be pressed onto the check valve. The pump is lowered into the well to the screened interval and rapidly cycled up and down a distance of 3 to 12 inches. The stroke length and speed can be adjusted for pumping effectiveness. Electric actuators can be used to reduce the effort involved. The pump should be moved to different levels in the screen to surge the entire screen. The pump can occasionally be lowered to the bottom of the well to pull out silt. Any silt that clogs the valve can be quickly rinsed out by the pump cycling; if the clog remains, the pump is easily retrieved and redeployed. The surging activity is usually continued until turbidity is lowered to a measurable range and cannot easily be lowered further. Further development or purging is then conducted with other pumps.

# 3.9 Wells with In-Place Plumbing and Pumps

Wells with in-place plumbing are commonly found at municipal water treatment plants, industrial water supplies, private residences, and other applications. Many permanent monitoring wells at active facilities are also equipped with dedicated in-place pumps.

A permanent monitoring well with an in-place pump may be treated as other monitoring wells without pumps. Since the in-place pump is generally hard-mounted at a pre-selected depth, it cannot be moved up or down during purging and sampling. If the pump inlet is above the screened interval, the well should be sampled using the Multi-Volume Purge method. If the pump intake is located within the screened interval, the well can be sampled using Low-Flow procedures. Known details of pump type and construction, tubing types, pump setting depths, and any other available information



about the system should be recorded in the field logbook and discussed with the project manager prior to sampling.

In the case of other types (e.g., municipal, industrial, and residential supply) of wells, there is typically not enough known about the construction aspects to apply the same criteria as used for monitoring wells. The volume to be purged in these situations therefore depends on several factors: whether the pumps are running continuously or intermittently and whether any storage/pressure tanks are located between the sampling point and the pump. The considerations and procedures to be followed when purging wells with in-place plumbing are discussed in Sections 3.9.1 and 3.9.2.

# 3.9.1 Continuously Running Pumps

If the pump runs more or less continuously, no purge (other than opening a valve and allowing it to flush for 3-5 minutes) is necessary. If a storage tank is present, a spigot, valve, or other sampling point should be found located between the pump and the storage tank. If no valve or spigot is present, locate and use the valve closest to the tank. Measurements of field parameters (if required) are recorded immediately prior to the time of sampling.

# 3.9.2 Intermittently or Infrequently Running Pumps

If the pump runs intermittently or infrequently, best judgment should be utilized to remove enough water from the plumbing to flush standing water from the piping and any storage tanks that might be present. Often under these conditions, 15 to 30 minutes of purging will be adequate. Measurements of pH, conductivity, temperature and turbidity should be made and recorded at intervals during the purge; the final measurements made at the time of sampling should be considered the measurements of record for the event.

# 3.10 Temporary Monitoring Wells General Considerations

Because temporary wells are typically installed for immediate sample acquisition, the procedures used to purge temporary groundwater monitoring wells may differ from those for permanent wells. Temporary wells include standard well screen and riser placed in boreholes created by hand augering or drilling, or they may consist of a drive rod and screen such as a direct-push Geoprobe Screen Point that is driven into place at the desired sampling interval. As aquifer water enters the sampler immediately upon deployment, the requirement to remove several volumes of water to replace stagnant water does not necessarily apply. In practice, developing and purging the well to usable turbidity levels will remove many times the water that would be removed in a Multi-Volume Purge with calculated well volumes. It is important to note, however, that the longer a temporary well is in place and not sampled, the more stagnant the water column becomes and the more appropriate it becomes to apply standard permanent monitoring well purging criteria to achieve representative aquifer conditions in the sample.

#### **Development of Temporary Wells**

In cases where the temporary well is to be sampled immediately after installation, purging is conducted primarily to mitigate the impacts of installation. In most cases, temporary well installation procedures disturb the existing aquifer conditions, causing extreme turbidity. The goal of purging is to reduce the turbidity and remove the volume of water in the area directly impacted by the installation procedure.



The following procedures have been found to be effective in developing and sampling small-diameter temporary wells where a peristaltic pump can be used. Turbidity can generally be lowered to 50 NTU at the time of sampling and turbidity less than 10 NTU is often achieved.

- 1. Cut peristaltic tubing long enough to reach the bottom of the well. Connect the tubing to a peristaltic pump and begin pumping at a high rate.
- 2. Use the tubing to vacuum out sediment at the bottom of the well.
- 3. Aggressively surge the end of the tubing in the screened interval by cycling the tubing rapidly up and down. Periodically repeat vacuuming of the well bottom.
- 4. When a visible break to a lower turbidity is observed, cease surging the well and begin lowering the pumping rate.
- 5. When the water clears (turbidity <100-200 NTU), begin raising the end of the tubing to the top of the water column.
- 6. Continue purging from the top of the water column, lowering the pump speed as necessary to achieve lower turbidity. When adequately low turbidity and stable water quality parameters have been achieved, sampling can proceed.

Where the water level is below the limit of suction in a small-diameter temporary well, a Geoprobe mechanical bladder pump can be used for purging and sampling. The well should first be developed with an inertial pump to remove the bulk of silt and suspended particles that could clog the check valves of the bladder pump. The inertial pump is used to vacuum out the bottom of the well and surged in the screened interval until a break to lower turbidity is observed prior to deployment of the bladder pump. Since the mechanical bladder pump requires cumbersome redeployment to change its pumping level, it should be deployed low enough in the water column that the water level will not be lowered below the pump during purging and sampling. The mechanical bladder pump is generally deployed above the screened interval to facilitate settling particles, but below the top of the water column to alleviate the need to reset the pump.

# Other Considerations for Direct-Push Groundwater Sampling

With certain direct-push sampling techniques, such as the Hydropunch and other discrete samplers used with cone-penetrometer rigs, purging is either impractical or impossible. The sampling device is simply pushed or driven to the desired depth and opened, whereupon the sample is collected and retrieved. As a result, some samples collected in this way may not be satisfactory or acceptable for certain analyses because the sampler may collect a turbid sample inappropriate for metals analyses or the sample may have inadequate volume to achieve desired reporting levels.

# 3.11 Wells Purged to Dryness

In some situations, even with slow purge rates, a well may be purged dry using the Multi-Volume Purge method or stable drawdown cannot be maintained using the Low-Flow method. In these cases, the well should be purged to dryness (evacuated) and sampled upon recovery of adequate volume for sampling. Sampling should occur as soon as adequate volume has recovered. The field parameters should be measured and recorded at the time of sample collection as the measurements of record for the sampling event.



Sampling under these conditions is not ideal and suitable qualifications of the data should be included in the report. Water cascading down the screen into the well may strip volatile compounds and elevate turbidity. Although suffering from other limitations, No-Purge methods may prove useful for these wells.

# 3.12 Additional Purging and Sampling Considerations Field Care of Purging Equipment

New plastic sheeting shall be placed on the ground surface around the well casing to prevent contamination of the pumps, hoses, ropes, etc., in the event they accidentally come into contact with the ground surface or, for some reason, they need to be placed on the ground during the purging event. Preferably, hoses used in purging that come into contact with groundwater be kept on a spool or contained in a large wash tub lined with plastic sheeting, both during transportation and during field use, to further minimize contamination by the transporting vehicle or the ground surface.

Careful consideration shall be given to using submersible centrifugal or bladder pumps to purge wells that are excessively contaminated with oily compounds as it may be difficult to adequately decontaminate severely contaminated pumps under field conditions. When wells of this type are encountered, alternative equipment such as bailers or peristaltic pumps should be considered.

# **Sample Preservation**

After sample collection, all samples requiring preservation must be preserved as soon as practical. Consult with the laboratory for the correct preservative for the particular analytes of interest. All samples preserved using a pH adjustment (except VOCs) must be checked using pH strips to ensure that they were adequately preserved. This is done by pouring a small volume of sample over the strip; do not place the strip in the sample. Samples requiring reduced temperature storage should be placed on ice immediately.

# 3.13 Special Sample Collection Procedures Order of Sampling with Respect to Analytes

In many situations when sampling permanent or temporary monitoring wells, sufficiently low turbidity is difficult to achieve and maintain. Removal and insertion of equipment after purging or during sampling may negate the low turbidities achieved during purging and elevate turbidity back to unacceptable levels. For this reason, it is important that special efforts be used to minimize any disturbance of the water column after purging and to fill sample containers for metals analysis first. The preferred order of sampling is metals, followed by other inorganic analytes, extractable organic compounds, then VOCs.

# **Filtering**

As many contaminants are known to sorb to soil particles, the normal goal of sampling is to reduce the presence of these particles (measured by turbidity) in order that the dissolved concentration of contaminants can be obtained. However, transport of contaminants sorbed on colloidal particles can be a means of contaminant transport at some sites. For this reason, turbidity should be reduced through careful purging rather than through filtering samples so the colloidal particles would be included in the sample.

As a standard practice, groundwater samples will not be filtered for routine analysis. Filtering will usually only be performed to determine the fraction of major ions and trace metals passing the filter, used for flow system analysis, and for modeling geochemical speciation. Filtration is not acceptable



to correct for improperly designed or constructed monitoring wells, inadequate well development, inappropriate sampling methods, or poor sampling technique.

When samples are collected for routine analyses and are filtered, both filtered and non-filtered samples will be submitted for analyses. Samples for organic compounds analysis should not be filtered. Prior to filtration of the groundwater sample for any reason other than geochemical speciation modeling, the following criteria must be demonstrated to justify the use of filtered samples for inorganic analysis.

- 1. The monitoring wells, whether temporary or permanent, have been constructed and developed in accordance with the applicable SOP.
- 2. The groundwater samples were collected using sampling techniques in accordance with this section, and the groundwater samples were analyzed in accordance with this SOP.
- 3. Efforts have been undertaken to minimize any persistent sample turbidity problems. These efforts may consist of redevelopment or re-installation of permanent groundwater monitoring wells or implementation of carefully conducted low-flow rate sampling techniques.

If filtration is necessary for purposes of geochemical modeling or other purposes, the following procedures are suggested.

- Accomplish in-line filtration by using disposable, high-capacity filter cartridges (barrel-type) or membrane filters in an in-line filter apparatus. The high-capacity barrel-type filter is preferred due to the higher surface area associated with this configuration. If a membrane filter is utilized, a minimum diameter of 142 millimeters is suggested.
- 2. When using pumps for sampling, the filter can generally be attached directly to the pump outlet. When sampling with a bailer or when otherwise required, an initial unfiltered sample with extra volume will be collected, and a peristaltic pump with filter used to decant and filter the sample to the final sample container.
- 3. Use a 0.45-micrometer ( $\mu$ m) pore-size filter to remove most non-dissolved particles. A 5- $\mu$ m or 10- $\mu$ m pore-size filter should be used for the purpose of determining colloidal constituent concentrations.
- 4. Fill the filter and rinse with approximately one additional filter volume prior to filling sample bottles.

Potential differences can result from variations in filtration procedures used to process water samples for the determination of trace element concentrations. A number of factors associated with filtration can substantially alter dissolved trace element concentrations including filter pore size, filter type, filter diameter, filtration method, volume of sample processed, suspended sediment concentration, suspended sediment grain-size distribution, concentration of colloids and colloidal-associated trace elements, and concentration of organic matter. Therefore, consistency is critical when comparing short-term and long-term results.



# **Bacterial Sampling**

Whenever wells (normally potable wells) are sampled for bacteriological parameters, care must be taken to ensure the sterility of all sampling equipment and all other equipment entering the well.

#### 4.0 DATA ACQUISITION, CALCULATIONS, AND DATA REDUCTION

Data is acquired in the field or office from the collection and analysis of samples. Other field data and observations are gathered and should be recorded in sampling notes and logs. Well volumes should be calculated per Section 3.5.1.

# 5.0 DATA/RECORDS MANAGEMENT

Information generated or obtained by field personnel will be organized and accounted for in accordance with established records management procedures found in SOP Field Documentation FD-01 or as specified in the project sampling and analysis plan. Field notes recorded in a bound field logbook will be generated, as well as chain-of-custody documentation and photographs, then stored in the project files.

#### 6.0 QUALITY CONTROL AND QUALITY ASSURANCE

Quality assurance and quality control procedures shall adhere to requirements in project quality assurance plans, a sampling and analysis plan, and other planning documents.

#### 7.0 NONCONFORMANCE AND CORRECTIVE ACTION

Nonconformance with this SOP may require corrective action as deemed necessary by the quality assurance manager or project manager. Notes, logs, and work will be reviewed periodically to ensure compliance.

#### 8.0 REFERENCES

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#### Attachments — Forms, Checklists, and Data Sheets

Example Well Development and Groundwater Sampling Form

Author	Reviewer(s)	Revisions (Technical or Editorial)
Ben Brantley	Jason Broughton/Kate Freeman	Revision 0 — February 2020 (Initial Issue)
Dave Fuehrer	Holly Brauer	Revision 1 – May 2020 (Editorial)

# Attachment A Example Well Development and Groundwater Sampling Form

# Attachment A: Example Groundwater Sampling Form

Purge water placed in drum#\_

l .												
DATE:				JOB NUMBER: PHASE: TASK:								
PROJECT:					EVENT:							
WELL ID:					LOCATION:							
WEATHER CONDITIONS	B:				AMBIENT TEMP:							
REVIEWED BY:					PERSONNEL:							
WELL DIA:			WELL DEVELOPMENT									
TOTAL DEPTH from TO	C (ft.):				START: FINISH:							
DEPTH TO WATER from TOC (ft.):					VOLUME PURGED (gal):							
LENGTH OF WATER CO	L. (ft.):				GROUNDWATER SAMPLING							
1 VOLUME OF WATER (	gal):				START:				FINISH:			
3 VOLUMES OF WATER	(gal):				VOLUME	PURGED	) (gal):		•			
					ANALYS	IS:						
MNA FIELD RESULT	s											
FERROUS IRON		_	CHLORIE				mg/L					mg/L
SULFIDE		mg/L	ALKALIN	ITY			mg/L					mg/L
SULFATE		mg/L	CO <sub>2</sub>				mg/L					mg/L
IN-SITU TESTING												
Circle one: DEVELO	PMENT	SAME	LING			□ Bailer	□ Pump	De	scription:			
Time (hh:mm):												
pH (units):												
Conductivity (mS/cm):												
Turbidity (NTU):												
DO (mg/L): Horiba												
YSI												
Temperature (C°):												
ORP (mV):												
Volume Purged (gal):												
Depth to Water (ft):												
Orion ORP: mV												
E <sub>H</sub>												
Rel mV												
								We	II Goes D	ry While	Purging	
SAMPLE DATA						□ Bailer			scription:			
							Filtered (0.45 µm) Remarks					
(1100)					•		•	,,,,,	. ,			
Purging/Sampling Device	e Decon P	rocess:		•		•				•		
COMMENTS:												

Page \_\_ of \_\_



# Standard Operating Procedure FT-02 Water Quality Parameter Testing

These standards will ensure continuity within the organization.

#### **Preamble**

This standard operating procedure (SOP) is designed to provide the user procedures on how to collect water quality parameters. Before using this SOP and as part of the due diligence, the user is required to determine whether state and federal minimum parameter collection standards need to be met. If a difference exists between the SOPs herein and the state and/or federal SOPs, the state and federal SOPs takes precedent.

This SOP describes the activities and responsibilities pertaining to collecting water quality parameter data. Deviations from this SOP must be approved by the parties responsible for this task; i.e., Project Manager and/or Program Quality Manager.

## 1.0 SCOPE AND APPLICABILITY

This procedure provides guidance for expected sampling methods and protocols by all personnel related to the measurement of water quality parameters.

Field measurements of water quality parameters are commonly performed to evaluate surface water, groundwater, and drinking water. These tests are often performed to evaluate basic water quality parameters, to evaluate natural attenuation parameters, and to assess the presence of pore water entering a well.

As professional guidance for specific activities, this procedure is not intended to obviate the need for professional judgment during unforeseen circumstances. Deviations from this procedure while planning or executing planned activities must be approved by either the Project Manager (PM) or the Program Quality Manager and documented.

#### 1.1 Definitions

*Shall* or *must* — When these words are associated with a procedure or other item, the item is mandatory, and performance is expected in all cases. Deviations from the SOP containing these words shall be documented.

Should or may — When these words are used, the referenced item is recommended or suggested, but not mandatory.

Barometric Pressure (BP) — The density of the atmosphere, which varies according to altitude and weather conditions.

Conductivity/Specific Conductance — A measure of the ability of water to pass electrical current, which increases with the amount of dissolved ionic substances (i.e., salts). The conductivity of water increases with increasing temperature.

Continuing Calibration Verification (CCV) — After use, the instrument or meter calibration is checked or verified by measuring a calibration standard of known value as if it were a sample and comparing the measured result to the calibration acceptance criteria for the instrument/parameter.



Initial Calibration (IC) — Before use, the instrument or meter electronics are adjusted (manually or automatically) to a theoretical value (e.g., DO saturation) or a known value of a calibration standard. An IC is performed in preparation for the first use of an instrument or if a calibration verification does not meet acceptance criteria.

Initial Calibration Verification (ICV) — The instrument or meter calibration is checked or verified directly following IC by measuring a calibration standard of known value as if it were a sample and comparing the measured result to the calibration acceptance criteria for the instrument/parameter. If an ICV fails to meet acceptance criteria, immediately recalibrate the instrument using the applicable initial calibration procedure or remove it from service.

Total Dissolved Solids — A measure of the quantity of materials in water that are either dissolved or too small to be filtered.

Turbidity — Measure of the clarity of water in Nephelometric Turbidity Units (NTUs). Potable water typically has NTU values between 0.0 and 0.3 NTUs, depending on the state or regulatory program.

#### 1.2 Related SOPs

FD-01 Field Documentation

FT-01 General Field Testing

# 1.3 Health and Safety

Health and safety considerations will vary according to the individual sampling sites and equipment used. Personnel shall review the site-specific Health and Safety Plan (HASP) to become familiar with the health and safety requirements, if available. Make note of any known or potential hazards listed in the HASP. Field personnel shall bring to the site any personal protective equipment outlined in the HASP or Sampling Plan appropriate for the hazards expected to be encountered during fieldwork activities. Every effort should be taken to minimize dermal contact with the water to be sampled and the standards used to calibrate equipment.

#### 1.4 Cautions

Standards used to calibrate equipment should be used and stored in accordance with manufacturer's instructions. Additionally, standards cannot be used if the storage expiration dates have been exceeded.

Field personnel must ensure that all equipment is in proper working condition, calibrated, and that batteries are properly charged before using the equipment.

#### 1.5 Interferences

During field testing, water quality data that is documented from field testing equipment may be influenced by certain outside factors that are unrelated to the actual site water quality. Such parameters and equipment include the following:



#### **pH Meters**

- pH probes must always be kept immersed in storage solution when not in use and calibrating a dry electrode will yields inaccurate readings. If a probe goes dry, hydrate it for 3-4 hours prior to calibration.
- Coatings of oils, greases, and particles may impair the electrode's response. Pat the
  electrode bulb dry with lint-free paper or cloth and rinse with de-ionized water. For cleaning
  hard-to-remove films, use isopropyl alcohol very sparingly so that the electronic surface is
  not damaged
- Poorly buffered solutions with low specific conductance (less than 200 microSiemens per centimeter  $[\mu S/cm]$ ) may cause fluctuations in the pH readings. Equilibrate electrode by immersing in several aliquots of sample before taking pH.

# **Dissolved Oxygen**

- Dissolved gases (e.g., hydrogen sulfide, halogens, sulfur dioxide) are a factor with the performance of DO probes. The effect is less pronounced on optical DO meters. Meter type and potential interferences should be considered based on potential sulfate/sulfide or nitrate/nitrite reducing environments.
- Exposure of the sample to the atmosphere will cause elevated DO measurements.

# **Turbidity Meter**

If the weather is warm and humidity is high, condensation may collect on the cuvette. To avoid this, allow the sample to warm and dry the outside of the cuvette before making the measurement. One method used to accomplish this is to place the cuvette against one's body (armpits work well).

#### **Temperature**

Sample temperature will change rapidly when there are significant differences between the sample and ambient air.

#### 1.6 Personnel Qualifications

Personnel preparing SOPs must be knowledgeable of the procedures in this SOP and other EnSafe SOPs. Training for each SOP will be dependent upon the specific procedure and each SOP will stipulate the type of training required for the procedure.

Field personnel are responsible for conducting water quality parameter testing procedures according to this SOP and the site-specific Sampling Plan. If, based on their best professional judgment, procedures to this SOP need to be modified in the field, the Field Manager or Project Manager will be notified of the deviations and the changes recorded in the field records. In addition, Field personnel should also be able to recognize problems with test equipment and have someone available for basic troubleshooting and repair.

# 2.0 APPARATUS AND MATERIALS

Field personnel shall consult the Work Plan and/or Sampling Plan to review the equipment requirements for the sampling procedures to be followed during the sampling effort. An example Field form for documenting calibration and recording the parameter testing results can be found in



#### Attachment 1.

Only indelible ink should be used when filling out the calibration and sampling logs.

The specific apparatus and materials required will depend on the water quality parameters being monitored. Table 1 shows the common equipment used in water quality parameter testing.

Table 1 Water Quality Parameter Testing — Common Equipment								
Water Quality Parameter Instrument	Calibration Standards Required	Other Equipment						
pH Meter	Yes — 3-Point Standards depending on sample range. Calibration must cover the range to be measured. If samples are above or below typical buffer standards (4, 7 and 10), special order buffers that fall outside sample pH range.	Container or flow thru cell for holding sample						
Specific Conductance	Yes	Container or flow thru cell for holding sample						
Oxidation-Reduction Potential Meter	Yes	Container or flow thru cell for holding sample						
Turbidity Meter	Yes	Container or flow thru cell for holding sample						
Dissolved Oxygen	No	Container or flow thru cell for holding sample						
Thermometer	No	Container or flow thru cell for holding sample						
Flow Rate	No	Calibrated Container						

Field equipment are required to be decontaminated before, during (between samples), and after sampling events. Field personnel need to be familiar on how to operate the equipment and in a safe manner. If field personnel are unsure of the operating requirements the Field and/or Project Manager should be contacted for assistance. Make sure the proper sampling equipment is used for the task: if not the Field and/or Project Manager need to be informed.

#### 3.0 PROCEDURES

#### 3.1 Instrument or Method Calibration

Most monitoring instruments require calibration before use, and this calibration must be conducted in the field under the ambient climatic conditions that will be present during field sampling. Calibration of monitoring instruments shall be performed in accordance with the manufacturer's specifications and recorded in the in the field logs. Site-specific instrument calibration requirements should be specified in the Sampling Plan. The following minimum calibration requirements apply to the various types of meters used to gather water quality measurements.

#### 3.1.1 Calibration Checks

Calibration checks are conducted by measuring a known standard. They must be completed after calibration and should be performed at least one other time (i.e., after lunch) and anytime suspect measurements are encountered. Table 2 provides general acceptance ranges to be used during calibration checks. If a meter is found to be outside of the acceptance range, the meter **must** be recalibrated. If the meter remains out of range, the project manager and/or the supplier of the meter should be contacted to determine alternative measures.



Table 2 Calibration Check Acceptance Limits			
Parameter Acceptance Criteria			
Dissolved Oxygen	±0.3 mg/L of the theoretical oxygen solubility		
Oxidation-Reduction Potential	±10 mV from the theoretical standard value at that temperature		
pH	±0.2 Standard pH Units		
Specific Conductance	±5% of the standard		
Turbidity	to 10 NTU: ±10% of the standard. 11 to 40 NTU: ±8% of the standard 41 to 100 NTU: ±6.5% of the standard		

Notes:

mg/L = milligrams per liter

mV = millivolts

NTU = nephelometric turbidity units

#### 3.1.2 pH Meters

- For the most accurate of pH measurements, pH meters should receive a three-point calibration. However, if a two-point calibration will bracket the sample pH of the site, a two-point calibration is acceptable. Three-point calibrations typically include calibrating to solutions of pH 7.00, 4.00, and 10.00. If sample pH is outside the calibration range of the solution standards, special buffers must be ordered to bracket the pH. Some meters will report the slope of the calibration and this may be used in checking the meter calibration (refer to the meter's manual). When performing an ICV, the result must be within  $\pm 0.2$  pH units of the stated buffer value.
- pH meters should be calibrated across the range of values to be measured. The maximum and minimum calibration solutions shall be outside the range of anticipated values. For example, if the expected range is between 7.50 and 9.00, the 7.00 and the 10.00 standard should be used for calibration. Perform the IC using at least two buffers, and always use the pH 7.00 buffer first. A reading that is above the maximum (or below the minimum) calibration standard is an estimate only and is not valid. This condition requires obtaining a new standard that is above (or below) the reported value, depending on the measurement
- A percent slope of less than 90 percent indicates a bad electrode that must be changed or repaired. If percent slope cannot be determined, or the manufacturer's optimum specifications are different, follow the manufacturer's recommendation for maintaining optimum meter performance.

#### 3.1.3 Specific Conductivity Meters

- For IC, when the sample measurements are expected to be 100 μS/cm or greater, use two standard potassium chloride (KCl) solutions that bracket the range of expected sample conductivities. Calibrate the instrument with the first standard. Verify the calibration of the instrument with the second standard, bracketing the range of expected sample values.
- If the instrument can be calibrated with more than one standard, choose additional calibration standards within the range of expected sample values.
- When the sample measurements are expected to be less than 100 μS/cm, based on previous measurements at the same site/location, a lower bracket is not required, but one standard KCl solution that is within the range of expected measurements should be used for the IC



and the ICV.

- Accept the calibration if the meter reads within ±5 percent of the value of any calibration standard used to verify the calibration.
- Most field instruments read conductivity directly. Record all readings and calculations in the calibration forms.
- For CCV, check the meter with at least one KCl standard with a specific conductance in the range of conductivity measured in environmental samples. The reading for the calibration verification must also be within ±5 percent of the standard value.
- If new environmental samples are encountered outside the range of the IC, verify the instrument calibration with two standards bracketing the range of sample values. If these calibration verifications fail, recalibrate the instrument.

# 3.1.4 Dissolved Oxygen Meters

- Before calibrating, check the probe membrane for bubbles, tears, or wrinkles.
   These conditions require replacement of the membrane in accordance with the manufacturer's directions.
- If the meter provides readings that are off-scale, will not calibrate, or drift, check the leads, contacts, etc., for corrosion and/or short circuits. These conditions require replacement maintenance in accordance with the manufacturer's directions.
- Most DO meters must be calibrated based on an environment of 100 percent humidity and a known elevation and BP. Place the probe in the calibration container with a moist towel and allow the probe to remain, undisturbed, for 10 to 20 minutes, this insures 100 percent humidity.
- The IC is an air calibration at 100% saturation. Before use, verify the meter calibration in water-saturated air to make sure it is properly calibrated and operating correctly. Make a similar verification at the end of the day or sampling event. Follow the manufacturer's instructions for your specific instrument. Allow an appropriate warm up period before IC. Wet the inside of the calibration chamber with water, pour out the excess water (leave a few drops), wipe any droplets off the membrane/sensor and insert the sensor into the chamber (this ensures 100 percent humidity). Allow adequate time for the DO sensor and the air inside the calibration chamber to equilibrate. Once the probe/calibration chamber is stable at ambient temperature, check the air temperature and determine, from the DO versus temperature table (see Attachment 2) what DO should measure. The acceptance criterion for DO ICV is ±0.3 milligrams per liter (mg/L).
- Use the same procedure as above for CCV.



# 3.1.5 Oxidation Reduction Potential (ORP) Meters

- Verify electrode response before use in the field.
- Equilibrate the standard solution to the temperature of the sample. The standard solution is based on a 25° Celsius (°C) temperature; however, the calibration solution standard's value will require adjustment based on the temperature.
- Immerse the electrodes and gently stir the standard solution in a beaker (or flow cell). Turn the meter on, placing the function switch in the millivolt (mV) mode.
- Let the electrode equilibrate and record the reading to the nearest millivolt. The reading must be within ±10 mV from the theoretical redox standard value at that temperature. If not, determine the problem and correct it before proceeding. Switch to temperature display and read the value.
- Record the mV reading and temperature in the field notebook or in form. Rinse the
  electrode with distilled water and proceed with the sample measurement, unless using a
  flow cell. If a flow cell is used, rinse between sample locations. After recording the
  measured value, add 200 mV and record the corrected value on the field sheet as well.

# 3.1.6 Turbidity Meters

- Perform an initial calibration using at least two primary standards.
- If the instrument cannot be calibrated with two standards, calibrate the instrument with one standard and verify with a second standard.
- Perform an ICV by reading at least one primary standard as a sample. The acceptance criterion for the ICV depends on the range of turbidity of the standard value:
  - Standard Value = 0.1 to 10 NTU: the response must be within 10 percent of the standard;
  - Standard Value = 11 to 40 NTU: the response must be within 8 percent of the standard;
  - Standard Value = 41 to 100 NTU: the response must be within 6.5 percent of the standard; and
  - Standard Value greater than 100 NTU: the response must be within 5 percent of the standard.
- Determining the Values of Secondary Standards Use only those certified by the manufacturer for a specific instrument. Secondary standards may be used for CCVs. To initially determine the value of a secondary standard, assign the value that is determined immediately after an ICV or verification with primary standards. This is done by reading the secondary standard as a sample. This result must be within the manufacturer's stated tolerance range and ±10 percent of the assigned standard value. If the ±10 percent criterion is not met, assign this reading as the value of the standard. If the reading is



outside the manufacturer's stated tolerance range, discard the secondary standard.

• CCV — Perform a CCV using at least one primary or secondary standard. The calibration acceptance criteria are the same as those for an ICV.

# 3.2 Sample Collection

Samples will be collected using methods described in Work Plans and/or Sampling Plans. Equipment calibration and sample measurements will be performed as described in Sections 3.1 and 3.4; respectively. All calibration and sample measurement reading will be documented in a field log or sampling form.

# 3.3 Sample Handling and Preservation

Section 1.4 describes cautions regarding standard storage and expiration dates.

# 3.4 Sample Analysis

The following water quality parameter testing procedures are based on currently accepted techniques. The specific sampling protocols to be followed at a particular site may vary from what is specified herein based on the requirements of a state environmental agency, United States Environmental Protection Agency Region, client need/request, equipment, site conditions, and limitations. The Sampling Plan for a particular site should contain specific information on the sampling techniques, equipment, and protocols to be followed during sampling.

# 3.4.1 Direct Measurements

Direct measurements with meters are the most common methods and can be accomplished by placing a sample in a container with the probe or by allowing the water to flow past the probe in a flow cell. The use of a flow-through cell improves measurement quality by allowing the constant flow of water over the probes and reduces interaction of the sample with the atmosphere. Sample cups should be avoided, except for calibrating. The quantity of samples, timing, and methodology should be described in the project Sampling Plan.

Following calibration of required probes, connect the bottom flow-cell port to the discharge line of the pump. Connect the top port to a discharge line directed to a bucket to collect the purge water. Allow the flow cell to completely fill. As the water flows over the probe, record the measurements. Continue to record the measurements at regular intervals, as specified in the Sampling Plan.

When the ambient air temperatures are much higher or lower than the temperature of the water sample, it is best to keep the length of tubing between the wellhead and the flow cell as short as possible to prevent heating or cooling of the water. Tubing and flow-through cell should not be exposed to direct sunlight, particularly in the summer, if possible, to avoid heating of water samples.

# 3.4.2 Possible and Suspected Ranges

The concentration for each parameter range should be known so that concentrations outside of the range can be noted. Table 3 presents the maximum range of the parameter in sample. The table also presents the suspected range. Measurements outside of the maximum/minimum range should be considered in error and the measurement method should be checked. Concentrations outside the normal range should be treated as suspect but may be the result of contaminant impact. For example, a pH of 2.0 would be out of the normally suspected range for sample but not at a site impacted with an acid.



	Table 3 Minimum and Maximum Result Ranges						
Parameter	Units	Possible Min	Possible Max	Normal Min	Normal Max	Notes	
Dissolved Oxygen	mg/L	0.0	14.6 (0°C) 10.1 (15°C) 8.3 (2°C)	0.0	5	The colder the sample, the higher the DO reading.  DO greater than 1 mg/L, ORP positive should not have sulfur odor, sulfide, ferrous iron, and/or gray color.  DO less than 1 mg/L, ORP negative, may have sulfur odor, sulfide, ferrous iron, and/or gray color.	
pН	SU	0	14	5	9	pH values exceeding 10 could indicate grout contamination	
ORP	mV					DO greater than 1 mg/L, ORP positive should not have sulfur odor, sulfide, ferrous iron, and/or gray color.  DO less than 1 mg/L, ORP negative, may have sulfur odor, sulfide, ferrous iron, and/or gray color.	
Specific Conductance	μS/cm			varies	varies		
Temperature	°C	0	100	5	30		
Turbidity	NTU	0	Greater than 1,000	0	Greater than 1,000	50 NTU or greater suggests cloudiness.	

#### Notes:

mg/L = milligrams per liter

°C = degrees Celsius

DO = dissolved oxygen

SU = standard units

ORP = oxidation reduction potential

mV = millivolts

mS/cm = microSiemens per centimeter NTU = nephelometric turbidity units

# 4.0 DATA ACQUISITION, CALCULATIONS, AND DATA REDUCTION

Any observations made, or calculations/measurements performed in the field shall be documented in the field logs or on field forms.

# 4.1 Specific Conductivity Correction Factors

If the meter does not automatically correct for temperature (i.e., read Specific Conductivity) record Conductivity and adjust for temperature upon returning to the office. The following equation can be used to convert Conductivity to Specific Conductivity.

(Km)(C) K = 1 + 0.0191(T-25)

Where:



K = Conductivity in  $\mu$ mhos/cm at 25°C

Km = Measured conductivity in μmhos/cm at T degrees Celsius

C = Cell constant

T = Measured temperature of the sample in degrees Celsius

# 4.2 Percentage Difference Calculation

For evaluating slope of readings from either a flow cell or a sample cup.

$$\% \ Difference = \frac{(Highest \ Value - Lowest \ Value)}{Highest \ Value} \times 100$$

# 4.3 Convert Millimeters Mercury to Inches Mercury

To convert between millimeters of mercury (mmHg) and inches of mercury (inHg) use the formula below:

$$mmHg = inHg \times 25.4$$

#### 4.4 True Barometric Pressure

For converting BP obtained from a public domain source that is expressed in BP at sea level to BP at the subject site.

True 
$$BP = (BP) - \frac{(2.5 \times Local Altitude)}{100}$$

Where: BP is in mmHg and Local Altitude is in feet

Example: BP at site A is 30.49 inHq and elevation is 544 feet, calculate True BP

Convert inHq to mmqHq:

$$mmHg = 30.49 inHg \times 25.4 = 774.4$$

mmHg Calculate True BP:

TrueBP = 
$$(774.4 \text{ mmHg}) - [2.5 * (544 / 100)] = 774.4-13.6 = 760.8 \text{ mmHg}$$

# 4.5 True Oxidation Reduction Potential or Eh

ORP readings may be converted Eh for metals evaluation, such as prediction of oxidation state and speciation. For converting measured ORP reported by the multimeter to Eh (which accounts for the difference between the field and reference electrode voltages), add 200 mV to the measured field value:

Corrected ORP = Field ORP + 200 mV Do not forget to account for negative ORP values. (i.e. -75 mV + 200 mV = +125 mV)

# 5.0 DATA/RECORDS MANAGEMENT

Data will be recorded promptly, legibly, and in indelible ink on the appropriate field logs and forms. At the completion of a field effort, all field logs, field data forms, and calibration logs shall be scanned and made electronically available to the project team. The original field forms,



calibrations logs, and field logs will be maintained in the project file.

#### 6.0 QUALITY CONTROL AND QUALITY ASSURANCE

The Work Plan and Sampling Plan should specify the quality assurance/quality control procedures to be followed during the water quality parameter testing. Quality assurance/quality control can include self-checks such as calibrations of field monitoring instruments as described in earlier sections.

# 7.0 NONCONFORMANCE AND CORRECTIVE ACTION

Any deviations from the standard protocol, deviations from procedures specified in the Sampling Plan, or any problems that occur during procedure implementation must be documented in the field logs or on forms, and corrective action should be applied, if warranted. Alternatives to the procedures specified in the Sampling Plan may be acceptable if they conform to established field and sampling protocols. If used, alternative procedures must be approved by the Project Manager and be properly documented in the field logs and/or on forms.

# 8.0 REFERENCES

Florida Department of Environmental Protection, January 2017 Standard Operating Procedures available at: https://floridadep.gov/dear/quality-assurance/content/dep-sops

United States Environmental Protection Agency, Science and Ecosystem Support Division, Field Measurement Procedures available at: https://www.epa.gov/quality/quality-system-and-technical-procedures-sesd-field-branches

#### ATTACHMENTS — FORMS, CHECKLISTS, AND DATA SHEETS

Attachment 1 — Example Field Instrument Calibration Form

Attachment 2 — Solubility of Oxygen in Water at Atmospheric Pressure

Author	Reviewer	Revisions (Technical or Editorial)	
Alan Jacobs	Tina Cantwell Revision 0 – November 2016 (Initial Issue)		
Tina Cantwell	Ben Brantley	Revision 1 – July 2019 (Editorial/Re-format/Add Attachments)	

Attachment 1
Example Field Instrument Calibration Form

			Fie	ld Instrument (	Calibration Form			
Calib	rated by:		····	Equipment (Make	/Model/Serial#):			<del></del>
Date	·			Equipment (Make	/Model/Serial#):			
	pH (SU)		Standard: ± 0.2 s	tandard units	DO (mg/L)	Standard: ± 0.3	mg/L of theoretic	al
	Initial C	alibration	Initial Calibrat	ion Verification	IC (Temp:	)	ICV (Temp:	)
١.	Solution Lot	Reading	Solution Lot	Reading	Saturation	Reading	Theoretical	Reading
pH7					(%)	(%)	(mg/L)	(mg/L)
١.		-			100			
pH4								
						CCV (Temp:	)	
		Continuing Calib	ration Verification		Saturation	Reading		Acceptable
				Acceptable	(%)	(%)	Deviation	Variance (Y/N)
		Reading	Deviation	Variance (Y/N)	100			
pH7					Theoretical	Reading		Acceptable
					(mg/L)	(mg/L)	Deviation	Variance (Y/N)
pH4								
		• "						
	ORP (mV)		Standard: NA		Turbidity (NTU)		Standard: ±10%	of Standard
	IC Solution Lot:		ICV Solution Lot:					
	TCS		TCS			Initial C	alibration	
١.	(Std/Temp)	Reading	(Std/Temp)	Reading		Standard	Reading	1
	<b>CCV Solution Lot:</b>					Continuing Calib	ration Verification	
	TCS			Acceptable				Acceptable
	(Std/Temp)	Reading	Deviation	Variance (Y/N)	Standard	Reading	Deviation	Variance (Y/N)
	Conductivity (µ	S/cm) Standard	l: ± 5% of standa	rd value	Comments:			
	IC Solution Lot:		ICV Solution Lot:					
١.,	Standard	Reading	Standard	Reading				
	CCV Solution Lot:							
				Acceptable				
١.	Standard	Reading	Deviation	Variance (Y/N)				
Notes:	SL	solution lot			standard units		Nephelometric Turbidity Un	its
	TCS Std	temperature corrected st standard	andard		millivolts percent		degrees Celsius microsiemens per centimet	er (temperature corrected)
1	Tomn	temperature			milligrams per liter	po/ ciii	per ceriamet	(somporousine confected)

Attachment 2 Solubility of Oxygen in Water at Atmospheric Pressure

Temperature (Degrees Celsius)	Water at Atmospheric Pressure  Oxygen Solubility (Milligrams per Liter)
0	14.621
1	14.216
2	13.829
3	
	13.46
4	13.107
5	12.77
6	12.447
7	12.139
8	11.843
9	11.559
10	11.288
11	11.027
12	10.777
13	10.537
14	10.306
15	10.084
16	9.87
17	9.665
18	9.467
19	9.276
20	9.092
21	8.915
22	8.743
23	8.578
24	8.418
25	8.263
26	8.113
27	7.968
28	7.827
29	7.691
30	7.559
31	7.43
32	7.305
33	7.183
34	7.065
35	9.65
36	6.837
37	6.727
38	6.62
39	6.515
40	6.412
41	6.312
42	6.213
43	
	6.116
44	6.021
45	5.927
46	8.835
47	5.744
48	5.654
49	5.565
50	5.477



# Standard Operating Procedure (SOP) Aquifer Characterization Specific Capacity Testing

#### **Preamble**

This standard operating procedure (SOP) represents EnSafe's minimum standard of practice for measuring the specific capacity of an aquifer.

# 1.0 SCOPE AND APPLICABILITY

Specific capacity is defined as the amount of yield per unit of drawdown of a particular well. Specific capacity tests involve pumping a well at a consistent rate for a short period of time and measuring the water level when drawdown has stabilized. Specific capacity tests are advantageous because they can be conducted while wells are being developed or purged for sampling and automatic data logging equipment is not necessary. Specific capacity testing of a well should be considered if the well is capable of sustaining a measurable yield, and if the pump is capable of maintaining a consistent flow rate. Specific capacity testing can be used to:

- determine the yield or maximum pumping rate a given well will sustain
- obtain preliminary estimates of aquifer parameters such as transmissivity and hydraulic conductivity
- determine well efficiency

The need for, and execution of, specific capacity tests should be evaluated on a case-by-case basis. Further descriptions of specific capacity tests are included in Heath (1987), Driscoll (1986), and Nielsen (1991). Procedures for conducting these tests can be found in these references and in Section 7 of this SOP.

# **1.1** Definitions and Acronyms

gpm — gallons per minute

Hydraulic Conductivity (K) — A measure of the rate at which water can move through a permeable medium (aquifer). It is presented in the units of length divided by time such as feet per day.

IDW — investigation derived waste

Specific Capacity — A measure of a well's yield per unit of drawdown during pumping. It is often presented as gpm per foot of drawdown.

Standard Operating Procedure (SOP) — A document which gives a step-by-step description of how a specific operation, method, or procedure is performed.



*Shall* or *must* — When these words are associated with a procedure or other item, the item is mandatory and expected to be performed in all cases. Deviations from the SOP containing these words shall be documented.

*Should* or *may* — When these words are used, the referenced item is recommended or suggested, but not mandatory.

Transmissivity (T) — The rate at which water is transmitted through a unit width of an aquifer. The transmissivity is equal to the hydraulic conductivity of an aquifer multiplied by the aquifer's saturated thickness. It can have the units of  $(length)^2$  per time or volume per time per length (gpm/foot).

#### 1.2 Related SOPs

FS-01-01 Procedures for General Sampling

FS-03-01 Groundwater Sampling FT-01-01 General Field Testing FD-01-01 Field Documentation

# **1.3** Health and Safety

Because potentially-contaminated well water will be pumped during testing, specific capacity tests should be conducted following a site-specific health and safety plan and/or the safe work assessment permit (SWAP). All measures employed to address known or unidentified health and safety concerns during field work shall be recorded in the field logbook and/or on appropriate field forms.

#### 1.4 Cautions

Personnel should allow sufficient time to perform specific capacity tests to ensure the test is representative of the formation and not the sand pack of the well.

# 1.5 Interferences

The most important factor contributing to invalid specific capacity data is a failure to maintain a constant discharge flow rate throughout the test. Drawdown in the well is proportional to and dependent upon the discharge rate. When specific capacity calculations are made, one discharge rate and one corresponding drawdown value are used. Therefore, if the discharge rate varies during the test, the discharge rate will be difficult to select and the stabilized drawdown will not be representative.

Another potential cause for error is unstable drawdown. Equations for specific capacity test results assume the water level in the well has reached steady state when the drawdown measurement is recorded. A good rule of thumb is that water level measurements within 0.03 feet of each other over a 10-minute interval can be considered stable. While this rule works for most situations, stabilization is a subjective judgment and should be made by qualified personnel.



# **1.6** Personnel Qualifications

Personnel must be knowledgeable of the procedures in this SOP. Personnel should have proper training in conducting specific capacity tests and be proficient at using water level meters, calculating flow rates or reading flow meters, and operating the selected pump type.

#### 2.0 APPARATUS AND MATERIALS

All equipment used during specific capacity testing should be tested and shown to be in good working order before test implementation. Any equipment to be placed in the well (e.g., water level indicators, pumps, and discharge tubing) should be decontaminated before use.

During specific capacity tests, water level measurements are collected by hand using an electronic water-level indicator. Water levels should be consistently measured from a known elevation point such as the top of the well casing.

Pumps that can maintain a consistent flow rate (an electric submersible or peristaltic pump for example) should be used to pump the wells. Pumps should be supplied by a reliable power source that will not be interrupted during testing. Pump discharge flow control should be stable and fully adjustable throughout the pump's discharge range.

An accurate method of flow measurement should be applied during specific capacity testing. Inline, direct-reading, flow meters provide the quickest, reasonably-accurate flow readings. For high-flow conditions (>10 gallons per minute [gpm]) and if total flow volume is desired, a turbine water meter is recommended. A variable area flow meter with integral needle valve control is a good choice for flow rates less than about 20 gpm.

Accurate flow rates can be calculated by hand using a container of known volume and a stopwatch. In this case the flow rate is equal to the volume of the container divided by the time it takes to fill the container.

Before testing, arrangements must be made for storage and/or disposal of water purged during the test. This water is often considered investigation derived waste (IDW) and should be handled according to site-specific IDW disposal protocols.

# 3.0 PROCEDURES

This section describes the sample collection procedures to follow when performing specific capacity tests. The following sampling procedures are based on currently accepted techniques. The specific sampling protocols to be followed at a particular site may vary from what is specified herein based on the requirements of a state environmental agency, U.S. Environmental Protection Agency region, or client need/request. The SAP for a particular site should contain specific information on the sampling techniques, equipment, and protocols to be followed during sampling.

# **3.1 Instrument or Method Calibration** (Not applicable)

# 3.2 Specific Capacity Testing

The procedures outlined below detail necessary steps conducted during specific capacity tests.



- 1. If the well is not vented to the atmosphere, open the well at least 30 minutes before testing to allow equilibration.
- 2. Measure the depth to water with a decontaminated water level indicator.
- 3. Insert the decontaminated pump and/or tubing in the well.
- 4. Measure the water level again. If the depth to water is > 0.05 feet different from that measured in step 2, then wait till the well recovers.
- 5. Start pumping and maintain a constant flow rate. After a few minutes of pumping, drawdown should be equivalent to between 10 and 20% of the aquifer's thickness. For example, drawdown should be between 4 and 8 feet in a 40-foot thick aguifer.
- 6. If drawdown exceeds 30% of the aquifer's thickness within the first 5 minutes of pumping, then shut off the pump, wait for recovery, and restart the test at a lower pumping rate.
- 7. Record the time since pump start-up and the corresponding drawdown measurement every 5 to 10 minutes during the test.
- 8. Continue pumping and recording time/drawdown measurements until the water level stabilizes (typically, measurements within 0.03 feet of each other per 10 minute interval can be considered stable; however, this is a subjective judgment and should be made by qualified personnel). If this condition is not met within one hour after pump start-up, then the aquifer is of limited extent or the pumping rate is slightly high.

# **3.3 Sample Handling and Preservation** (Not Applicable)

# 3.4 Data Analysis/Calculations

Aquifer parameters can be calculated from the specific capacity test data using a computer program (TGUESS) developed by Bradbury and Rothschild (1985) based on equations presented in Lohman (1972). Drawdown in the well being purged and the duration of pumping are entered into the computer program with other variables that characterize the aquifer (storage coefficient and aquifer thickness) and the pumping system (pumping rate, well dimensions, and well-loss coefficients). The program output includes estimates of specific capacity, transmissivity, and hydraulic conductivity. The analysis of specific capacity test results, and their application, should be reviewed through the appropriate peer review process before report production.

# 4.0 DATA/RECORDS MANAGEMENT

All information relative to a particular specific capacity test including personnel, decontamination procedures, pump operation details, procedural deviations, and the pumping rate, time, and water level at stabilization must be recorded in the site-specific field logbook. Field information such as weather conditions and other activities occurring during testing should be recorded as well. A running log of water levels, drawdowns, pumping rates, and their corresponding measurement times should be recorded on the attached *Specific Capacity Test Data Sheet*.



# 5.0 QUALITY CONTROL AND QUALITY ASSURANCE

Quality control of specific capacity tests will be ensured by:

- following the protocols outlined in this document
- using properly trained and qualified personnel to conduct tests and calculate the results
- conducting tests and reviewing results

# 6.0 NONCONFORMANCE AND CORRECTIVE ACTION

Any deviations from the SOP or standard protocol or other problems occurring during specific capacity testing must be documented in the field logbook. Corrective actions up to and including rerunning of a specific capacity test will be taken if warranted.

#### 7.0 REFERENCES

Bradbury, K.R. and Rothschild, E.R. (1985). A computerized technique for estimating the hydraulic conductivity of aquifers from specific capacity data, Ground Water, 23(2), pp. 240-246.

Driscoll, F.G., editor (1986). Groundwater and Wells, Johnson Filtration Systems, Inc., St. Paul, Minnesota. Chapters 8, 9, and 16.

Heath, R. C. (1987). Basic Groundwater Hydrogeology, U.S.G.S. Water Supply Paper 2220. 84pp.

Lohman, (1972). Ground-water Hydraulics, U.S. Geological Survey Prof. Paper 708. 45-46.

Nielsen, D. M., (1991). Practical Handbook of Groundwater Monitoring, Lewis Publishers, Inc., Chelsea, Michigan. Chapters 9 and 10.

# ATTACHMENTS — FORMS, CHECKLISTS, AND DATA SHEETS

Attachment 1 - Specific Capacity Test Data Sheet

Author	Reviewer(s)	Revisions (Technical or Editorial)
Bart Douglas	Allison Harris	Revision 0 — June 2006 (Initial Issue)
Bart Douglas	Ben Brantley	Revision 1 – September 2019

Attachment 1 - Specific Capacity Test Data Sheet					
Project #:		Date:		Client:	
Personnel: Well:			Site:		
Time	Time Since Start (min)	Depth to H <sub>2</sub> O (feet)	Drawdown (feet)	Discharge Rate (gpm)	Comments



# **Standard Operating Procedure FC-01 Decontamination of Field Equipment**

These standards will ensure continuity within the organization.

#### **Preamble**

This Standard Operating Procedure (SOP) represents EnSafe's minimum standard of practice. State and federal requirements may vary, as may project-specific work plans, all of which must be consulted before work begins. This SOP may be modified to meet regulatory, client, or project-specific criteria.

#### 1.0 SCOPE AND APPLICABILITY

The main objective of the decontamination SOP is to ensure that all equipment that may have contact with a sample during sample collection is free of contaminants and analytes that could impact study objectives. This overlaps with the main objective of the cleaning procedure, which is to ensure that equipment, before or after use, has been cleaned in such a manner that it is free of contaminants, and will not impact current or future sampling or endanger individuals handling the equipment. If there are procedures from a client, state, and/or federal agency that are not addressed in this SOP and are applicable to decontamination, they may be added as an appendix to the project sampling or quality assurance plans.

#### 1.1 Definitions

Sampling and Analysis Plan (SAP) — A plan that outlines the sampling procedures and protocols to be followed during a field effort.

*Shall* or *must* — When these words are associated with a procedure or other item, the item is mandatory, and performance is expected in all cases. Deviations from a procedure containing these words shall be documented.

Should or may — When these words are used, the referenced item is recommended or suggested, but not mandatory.

Standard Operating Procedure — A document that gives a step-by-step description of how a specific operation, method, or procedure is performed.

# 1.2 Related Standard Operating Procedures

FS-01	General Sampling	FS-09	Potable Water Supply Sampling
FS-02	Soil Sampling	FS-10	Contamination Surfaces Sampling
FS-03	Groundwater Sampling	FS-11	Waste and Investigation-Derived Waste Sampling
FS-04	Pore Water Sampling	FS-12	Per- and Polyfluoroalkyl Substance Sampling
FS-05	Diffusion Sampling	FS-14	Wastewater Sampling
FS-06	Sediment Sampling	FS-15	Tissue Sampling
FS-07	Soil Gas Survey	FQ-01	Quality Assurance/Quality Control Sampling
FS-08	Surface Water Sampling		



#### 1.3 Health and Safety

Before commencing any sampling effort, field personnel shall review the health and safety requirements, any site-specific Health and Safety Plans, Job Hazard Analyses, etc., to become familiar with the site hazards and safety requirements. Caution should be exercised, and all applicable safety procedures shall be followed. For concerns regarding specific health and safety issues, see the site-specific health and safety plan, as well as SOP FT-01 General Field Testing. If a site-specific safety plan is not available, consult the EnSafe Corporate Health and Safety Plan.

- Safety glasses with splash shields or goggles, disposable gloves, and safety boots shall be worn during all decontamination operations. Additional personal protective equipment (PPE) may be required per the site-specific SAP.
- No eating, smoking, drinking, chewing, or hand-to-mouth contact shall be permitted during cleaning operations.

#### 1.4 Cautions

Personnel shall inspect and familiarize themselves with all site-specific field equipment before entering the field. Care should be taken by personnel to protect themselves from inadvertent exposure to contaminated equipment received from a vendor or improperly decontaminated equipment received from a third party. Solvents, soap, and rinse waters used to clean equipment cannot be reused.

Personnel shall take appropriate precautions when handling, stowing, and/or transporting field equipment unless the equipment has been specifically identified as decontaminated or certified clean.

Decontaminated equipment shall only be handled by personnel wearing latex or nitrile gloves to prevent re-contamination.

Field personnel must be aware of special decontamination equipment and associated requirements when sampling per- and polyfluoroalkyl substances (PFAS) which is detailed in SOP FS-12.

#### 1.5 Interferences

None applicable to this SOP.

# 1.6 Personnel Qualifications

Personnel must be knowledgeable of the procedures in this SOP. Documentation of training and familiarization with this SOP can be found in the training file for each employee. This SOP applies to all EnSafe employees who participate in field equipment decontamination.

# 2.0 APPARATUS AND MATERIALS

Field personnel shall consult the site work plan and SAP to review the field equipment decontamination requirements for a specific project or job site. Recommendations for the types of cleaning supplies are discussed in this section. Field personnel must be aware of special decontamination equipment and associated requirements when sampling for PFAS, which are detailed in SOP FS-12.



- Analyte-Free (Deionized) Water is water that has been treated by passing through a standard deionizing resin column. At a minimum, the finished water should contain no detectable (i.e., at or above analytical detection limits) heavy metals or other inorganic compounds. Deionized water must be stored in clean glass or Teflon containers that can be securely closed before and after use. The use of containers made of materials other than glass or Teflon must be specified in the approved site-specific SAP. Deionized water may be applied from a Teflon squeeze bottle.
- Cleaning Utensils may include scrub pads, brushes, and buckets that may or may not be dedicated to a specific project. Projects requiring frequent sampling may dedicate cleaning utensils to avoid the possibility of cross-contamination from another site. Color-coding dedicated equipment and cleaning utensils will aid in site-specific identification.
- Decontaminated Equipment Storage and Materials may include aluminum foil, untreated butcher paper, clean (untreated) disposable plastic bags, or other untreated plastic wrap. Plastic bags shall not contact equipment to be used when volatile or extractable organic compounds are potential contaminants of concern. Plastic bags may be used on equipment that has been wrapped with foil or butcher paper. Decontaminated equipment is wrapped to prevent recontamination. If the decontaminated equipment is to be stored for any period of time, the wrapping should include the date on which it was decontaminated.
- Decontamination Pad is an area designated and constructed for field cleaning sampling and drilling equipment that is known or believed to be free of surface contamination. If possible, the pad should be constructed on a level paved surface and should facilitate the removal of wastewater. Sawhorses or racks constructed to hold equipment while being cleaned should be high enough above ground to prevent equipment from being splashed. If a temporary pad is constructed, it should be lined with a water-impermeable material (without seams) within the pad. This material should be easily replaced (e.g., disposable polyethylene plastic sheeting).
- Soap shall be a standard brand of phosphate-free laboratory detergent such as Liquinox. Use
  of another detergent must be justified and documented in the field logbooks, inspection
  forms, and/or investigative reports. Soap may be stored in its original container or in a highdensity polyethylene or polypropylene container. The soap should be poured directly from
  this container during use.
- Solvent shall be pesticide-grade isopropanol. Pesticide-grade isopropanol must be obtained
  from a laboratory supply vendor. Rubbing alcohol or other commonly available sources of
  isopropanol are not acceptable. Use of a solvent other than pesticide-grade isopropanol (e.g.,
  acetone, methanol) must be specified in the site-specific SAP. Solvent shall be stored in its
  original container until used in the field. Solvents may be dispensed from glass, Teflon, or
  stainless-steel containers. If a stainless-steel device is used, any gaskets that may contact
  the solvents must be constructed of inert material.
- Tap Water may be used from any municipal water treatment system. Use of an
  untreated potable water supply is not an acceptable substitute for tap water; however, bottled
  water (i.e., drinking water, distilled water) is an acceptable substitute. Tap water may be
  kept in clean tanks, hand-pressure sprayers, or squeeze bottles, or applied directly from a
  hose.



#### 3.0 PROCEDURES

The following procedures will be used for decontaminating all sampling equipment. Any deviation from these procedures must be outlined in the site-specific SAP. All deviations from these procedures should be documented in the field notes and communicated to the project manager. Field personnel shall review the field decontamination requirements in the SAP prior to commencing field work activities.

When possible, clean equipment and materials should be transported to the field so that an entire study can be conducted without the need for field decontamination.

# 3.1 Instrument or Method Calibration

Not applicable to this SOP.

# 3.2 Decontamination Procedures

The following procedures are to be used when sampling equipment is decontaminated. All sampling equipment must be decontaminated between sample locations and between sample intervals. At no time shall sampling equipment that has been in contact with contaminated or potentially contaminated media be used for sample collection without being properly decontaminated. These procedures should be used to decontaminate all sampling equipment constructed of stainless steel, carbon steel, Teflon, polyvinyl chloride (PVC), Acrylonitrile Butadiene Styrene (ABS), or other plastics. Equipment should be disassembled to the extent that access is gained to all surfaces that may contact contaminated media.

- 1. Clean with tap water and soap using a brush to remove all debris and surface films. Stainless and carbon steel equipment may be steam cleaned (soap and high-pressure hot water) as an alternative to brushing. Sampling equipment that is steam cleaned should be placed on racks or saw-horses at least 2 feet above the floor of the decontamination pad. Teflon, PVC, ABS, or other plastic items should not be steam cleaned.
- 2. Rinse thoroughly with tap water.
- Rinse thoroughly with deionized water.
- 4. Rinse thoroughly with solvent if appropriate. Do not rinse PVC or plastic items with solvent.
- 5. Rinse thoroughly with deionized water. If sufficient volumes of deionized water are not available, solvent-rinsed equipment should be allowed to completely air dry.
- 6. Remove the equipment from the decontamination area and wrap with aluminum foil, untreated butcher paper, or other acceptable material.



# 3.2.1 Decontamination of Sample Tubing

Unless the manufacturer certifies tubing as clean, sample tubing will require decontamination before use. The tubing should be cut to appropriate lengths to accommodate the monitoring wells. Before decontaminating the tubing, check the tubing for discoloration and elasticity. Discard tubing that is discolored or has lost its elasticity.

# **Tubing Exterior**

- 1. Decontaminate the exterior of the tubing by soaking in soapy water mixture. Use a brush to remove particulates if needed.
- 2. Rinse the exterior of the tubing with tap water.

# **Tubing Interior**

- 1. Mix a solution of tap water and soap.
- 2. Connect one end of the tubing to the influent end of the pump.
- 3. Place other end of the tubing into the soapy water mixture and allow the pump to draw the water through the tubing. The soapy water mixture should pass through the entire length of the tubing prior to entering the pump. Recycle the effluent from the pump by connecting a length of tubing at the pump effluent to the soapy solution.
- 4. Place the other end of the tubing into tap water and allow the pump to draw the tap water through the tubing. The tap water volume should be twice the volume of the soapy water mixture.
- 5. Follow the same procedure described above to pump deionized water through the Teflon tubing except do not recycle the deionized water. The volume of deionized water should be equal to that of the tap water.

When possible, tubing should be dedicated to each groundwater monitoring well to eliminate the need for decontamination and possible cross-contamination. If dedicated sample tubing is stored for long periods of time, the tubing should be decontaminated before use.

# 3.2.2 Decontamination of Sampling Pumps

Sampling pumps pose unique problems. Pumps may require disassembly to gain access to all parts that come in contact with contaminated or potentially contaminated media.

# **Pump Exterior**

- 1. Scrub with soapy water mixture using a brush to remove all debris and surface films
- 2. Rinse thoroughly with tap water
- 3. Rinse thoroughly with deionized water
- 4. Air dry



# **Pump Interior**

If a pump is used for purging and sampling, disassemble pump to gain access to all internal and external parts that may contact the sample media if possible. If the pump cannot be disassembled, then apply the following procedures.

- 1. Pump several gallons of soapy water
- 2. Pump several gallons of tap water
- 3. Pump several gallons of deionized water
- 4. Remove the equipment from the decontamination area, allow to air dry where possible and wrap with aluminum foil or other acceptable material.

# 3.2.3 Decontamination of Drilling Equipment

The following is the standard procedure for field cleaning augers, drill stems, rods, tools, and associated equipment.

- 1. Clean with tap water and soap, using a brush if necessary, to remove particulate matter and surface films. Steam cleaning (high-pressure hot water with soap) may be necessary to remove matter that is difficult to remove with the brush. Drilling equipment that is steam cleaned should be placed on racks or saw-horses at least 2 feet above the floor of the decontamination pad. Hollow-stem augers, drill rods, etc., that are hollow or have holes that transmit water or drilling fluids should be cleaned on the inside with vigorous brushing if possible.
- 2. Rinse thoroughly with tap water and allow to air dry where possible. The site-specific SAP will identify if additional decontamination (i.e., alcohol rinse, deionized water rinse) is required.
- 3. Remove from the decontamination pad and cover with clean, unused plastic. If not used immediately, the plastic should be secured to ensure that it stays in place.

# 3.2.4 Decontamination of Field Instruments

Field instruments include water level indicators, interface probes, etc. Follow manufacturer's recommendations for cleaning instruments. The following procedures should be performed at a minimum.

- 1. Wash equipment body, probes, and cables with soapy water mixture
- 2. Rinse thoroughly with tap water and allow to air dry where possible.
- 3. Store equipment in accordance with manufacturer's specifications or wrap with aluminum foil



# 3.2.5 Decontamination of Field Analytical Instruments

Field analytical instruments include pH meters, Dissolved Oxygen meters, conductivity meters, etc. Follow manufacturer's recommendations for cleaning instruments. The following procedures should be performed at a minimum.

- 1. Wipe the exterior of the instrument with a clean, damp cloth
- 2. Rinse the probe with analyte free water
- 3. Air dry

Each time the instrument is cleaned, check for and replace any desiccant.

# 3.2.6 Decontamination of Ice Chests and Reusable Shipping Containers

The following procedures should be performed at a minimum.

- 1. Wash the interior and exterior of ice chests/ shipping containers with soapy water mixture
- 2. Rinse thoroughly with tap water
- 3. Air dry

If the container becomes severely contaminated with wastes, clean as thoroughly as possible, render unusable, and properly dispose.

# 3.3 Disposal of Decontamination Fluids

The site-specific SAP should specify how spent decontamination fluids will be handled and disposed. Spent decontamination fluids may need to be treated as investigation-derived waste (IDW) and handled accordingly. If solvents are used in the decontamination process, the solvents shall be collected, labeled, and stored separately for proper disposal. Personnel shall review the field decontamination and IDW handling requirements in the SAP before commencing field work activities.

# 4.0 DATA ACQUISITION, CALCULATIONS, AND DATA REDUCTION

Not applicable to this SOP.

#### 5.0 DATA/RECORDS MANAGEMENT

Document cleaning procedures are described below for the indicated activities. See SOP FD-01 for additional information about required records and retention of documents.

# 5.1 Field Equipment

# **In-Field Cleaning**

- 1. Describe the procedure(s) that are used to clean equipment
- 2. Record the date and time that equipment was cleaned

# **In-House Cleaning**

- 1. Retain any cleaning certificates, whether from a laboratory or commercial vendor
- 2. Describe the procedure(s) that are used to clean equipment
- 3. Record the date that the equipment was cleaned



#### 5.2 Sample Containers

- 1. Retain the packing slips, lot numbers of each shipment, any certification statements provided by the vendor, and the vendor cleaning procedures for precleaned containers.
- 2. If containers are certified clean by the laboratory the laboratory must record:
  - Type of container and date cleaned
  - SOP used
  - Date cleaned and person responsible for cleaning
  - Lot number (date of cleaning may be used) of the batch of containers that were cleaned using the same reagent lots and the same procedure
  - Results of quality control tests for the lot numbers
  - Any additional cleaning or problems that were encountered with a specific lot

# 5.3 Reagents and Other Cleaning Supplies

Maintain a record of the lot number with the inclusive dates of use for all acids, solvents, and other cleaning supplies.

# 6.0 QUALITY CONTROL AND QUALITY ASSURANCE

As described in FQ-01 Quality Assessment/Quality Control (QA/QC) Sampling, rinsate blanks will be collected at a frequency outlined in the site-specific SAP. A rinsate blank is a sample collected using organic-free water that has been run over/through sample collection equipment after the equipment has been decontaminated.

# 7.0 NONCONFORMANCE AND CORRECTIVE ACTION

Failure to use proper decontamination procedures can lead to cross-contamination of samples. Improperly decontaminated equipment can also lead to the spread of contamination to designated clean areas and to possible exposures of personnel to hazardous substances. If cross contamination is suspected or confirmed (i.e., from QA/QC sample results, data validation), all site field equipment shall be decontaminated and additional QA/QC samples (as discussed in Section 6 of this SOP and detailed in SOP FQ-01) should be collected to document that proper decontamination procedures have been followed.

# 8.0 REFERENCES

Florida Department of Environmental Protection. DEP-SOP-001/01, FC 1000, Cleaning/Decontamination Procedures. Effective Date April 16, 2018. Retrieved from https://floridadep.gov/dear/quality-assurance/content/dep-sops.

United States Environmental Protection Agency, Region 4. *Packing, Marking, Labeling and Shipping of Environmental and Waste Samples, LSASDPROC-209-R4*. Effective Date February 23, 2020. Retrieved from https://www.epa.gov/sites/production/files/2016-01/documents/field\_equipment\_cleaning\_and\_decontamination205\_af.r3.pdf.

# ATTACHMENTS — FORMS, CHECKLISTS, AND DATA SHEETS (None)

Author	Reviewer(s)	Revisions (Technical or Editorial)
Kate Freeman	Ben Brantley	Revision 0 – April 2006 (Initial Issue)
	Ben Brantley	Revision 1 – September 2019
	Holly Brauer	Revision 2 - June 2020 (Editorial)



# Standard Operating Procedure FD-01 Field Documentation

#### **Preamble**

This Standard Operating Procedure (SOP) represents EnSafe's minimum standard of practice. State and federal requirements may vary, as may project-specific work plans, all of which must be consulted before work begins. This SOP may be modified to meet regulatory-, client-, or project-specific criteria.

#### 1.0 SCOPE AND APPLICABILITY

This SOP provides personnel with guidance for documenting sampling activities and other data collection in the field. Proper field documentation is necessary for creating unequivocal, accurate, and methodical records and shall be performed during all field activities. Refer to the associated sampling or field-testing SOP for any requirements for chronological or sequential documentation of data. This procedure applies to all EnSafe employees who participate in field sampling efforts.

#### 1.1 Definitions

Sampling and Analysis Plan (SAP) — A plan that outlines the sampling procedures and protocols to be followed during a field effort.

Shall or must — When these words are associated with a procedure or other item, the item is mandatory, and performance is expected in all cases. Deviations from a procedure containing these words shall be documented.

Should or may — When these words are used, the referenced item is recommended or suggested, but not mandatory.

Standard Operating Procedure — A document that gives a step-by-step description of how a specific operation, method, or procedure is performed.

# 1.2 Related Standard Operating Procedures

The following are related EnSafe SOPs:

AD-02	Chain of Custody	FS-05 Diffusion Sampling
FD-02	Lithologic Logging	FS-06 Sediment Sampling
FQ-01	Quality Assurance/Quality Control Sampling	FS-07 Soil Gas Survey
FS-01	General Sampling	FS-12 Per- and Polyfluoroalkyl Substances Sampling
FS-02	Soil Sampling	FT-01 General Field Testing
FS-03	Groundwater Sampling	FT-02 Water Quality Parameter Testing

# 1.3 Health and Safety

Before commencing any sampling effort, field personnel shall review the health and safety requirements, any site-specific Health and Safety Plans, Job Hazard Analyses, etc., to become familiar with the site hazards and safety requirements. All measures employed to address known or unplanned health and safety concerns during field work shall be recorded in the field logbook, safe work assessment permit, and/or job hazard analyses.



#### 1.4 Cautions

In addition to field data, documentation must be provided for any activity that results in equipment damage, degradation of collected environmental samples, the possibility of invalid sample analytical results, or health and safety issues. Precautionary measures shall be recorded at the critical steps for the field procedures being performed. Custody of field documentation must always be maintained and copied to the electronic project file. Field personnel must keep documentation in a secure place when not in their personal possession.

Field personnel must be aware of special documentation equipment and precautions necessary when sampling for per- and polyfluoroalkyl substances (PFAS), which are detailed in SOP FS-12.

#### 1.5 Interferences

Improper field documentation can affect data quality, its usability, and site assessment interpretations.

# 1.6 Personnel Qualifications

Personnel must be knowledgeable of the procedures in this SOP. Documentation of training and familiarization with this SOP can be found in the training file for each employee. This procedure applies to all EnSafe employees who participate in environmental sampling and other data collection efforts.

#### 2.0 APPARATUS AND MATERIALS

Field personnel shall consult the site work plan and SAP to review the field documentation requirements for a specific project or job site. Field documentation may be recorded in a field logbook, on appropriate field forms, electronically, or using other media (e.g., photographs). If appropriate for the project, EnSafe personnel shall use only bound waterproof field logbooks.

#### 3.0 PROCEDURES

The procedures in this SOP will ensure that the history of a sample is clearly evident in the retained records and documentation and can be independently reconstructed.

#### **Criteria for All Documents**

- The following criteria apply to all types of documentation.
- Keep all applicable documentation available for inspection.
- Keep all original data and records as well as reduced or manipulated forms of the original data or records.
- Record enough information so that clarifications, interpretations, or explanations of the data are not required from the originator of the documentation.
- Clearly indicate the nature and intent of all documentation and all record entries.
- When appropriate, link citations to SOPs and other documents by the revision number, revision date, and complete name, reference, or publication number for the cited document.



- Retain copies of all revisions of all cited documents as part of the documentation archives.
- Sign, initial, or encode all documentation entries made to paper, electronic, or other records
  with a link indicating the name and responsibility of the author making the data entry,
  clearly indicating the reason for the signature, initials, or code (e.g., "sampled by," "released
  by," "prepared by," "reviewed by").
- Retain correspondence with regulators regarding approval to use alternative procedures for a project.
- Employ straightforward archiving of records to facilitate documentation tracking and retrieval of all current and archived records for purposes of inspection, verification, and historical reconstruction of all procedures and measurement data.
- Keep copies of original documentation, including that sent to or received from external parties.
- Use permanent ink for all paper documentation. Do not erase or obliterate entry errors on paper records.
- Link final reports, data summaries, or other condensed versions of data to the original sample data, including those prepared by external parties.

#### 3.1 Manual Documentation

Manual documentation includes records completed by hand such as field logbooks, field forms, sample labels, and chain-of-custody (COC) forms. When manually recording information, care should be taken to write legibly so that others will be able to read the written documentation. The following paragraphs provide general guidance and summarize manual documentation methods.

# Field Logbook

A separate field logbook is maintained for each project. If a project consists of multiple sites, a separate logbook may be designated for each site. For tasks such as water level measurements, multiple sites for one project may be recorded in one logbook.

- The Project Manager's name, the sample team leader's name (if applicable), the project name and location, and the project number should be entered on the inside of the front cover of the field logbook. The beginning and ending dates of activities in the logbook should be listed on the cover.
- The spine of the logbook should contain an abbreviated version of the cover information. For example, "NAS Pensacola, Site 1, 6/94 12/98."
- The EnSafe office address and phone number should be written inside the front cover in the event the logbook is lost.
- Each page in the logbook shall be numbered and dated. When the page numbers are handwritten, the numbers should be circled to prevent confusion with data entry.



- All entries must be legible, made with permanent ink, and contain accurate and inclusive documentation of project field activities.
- Begin each day with a new page. Each day will begin with the following information:
  - Date
  - Starting Time
  - Location
  - Weather conditions and approximate temperature
  - Name, affiliation, and designation of personnel onsite
  - If applicable, equipment calibration and equipment models used
  - Changes to instructions for site activities
  - Levels of personal protective clothing and equipment
  - A general title of first task undertaken (i.e., well installation at MW-12, sediment sampling at Wetland 4, Location 5)
- Make corrections by drawing a single line through the entry being corrected. Initial the correction.
- Provide an approximate scale for any diagrams or, if unknown, write "Not to Scale." Indicate north arrow on all maps and cross-sections. Label features on each diagram.
- At the end of each day's entries, draw a diagonal line and add your initials to fill in empty space on the page and indicate the conclusion of the day's entry and departure from the site.
- Since field records are the basis of future reports related to the project, all language should be objective, factual, and free of personal feelings or other terminology that might prove inappropriate.

Once completed, the field logbook becomes an accountable document and must be maintained as part of the official project file. All aspects of sample collection and handling shall be documented in the field logbook, along with visual observations, project-related conversations with the client, onsite contacts, EnSafe project manager, analytical laboratory, and media or private landowners (i.e., the public).

#### **Field Forms**

In addition to the field logbook, field forms and data sheets may be used by EnSafe personnel to document field activities. The following describe some of the field forms, which are provided as attachments to the corresponding SOPs (as indicated):

• Equipment Calibration Log (see SOP FT-01) — Field instruments will be calibrated daily before use according to the manufacturers' specifications. Instruments may also be calibrated during the day if field personnel consider it necessary. Instrument calibration will be recorded in the field logbook or on project-specific calibration logs.



- Boring Log (see SOP FD-02) The boring log form is used to document subsurface geology and drilling/sampling activities, monitoring well construction specifications, and general information pertaining to a particular soil boring or monitoring well boring location. Specifically, the boring log form documents the drilling/sampling method, lithologic description, boring/well depth, sample intervals, groundwater depth, and other boring details.
- Well Development/Groundwater Sampling Form (see SOP FS-03) The well
  development/groundwater sampling form is used to document site conditions and activities
  during monitoring well development and groundwater sampling. The form shall document
  site information and data including sampling personnel, the sampling equipment used, well
  construction information and/or well volume, groundwater quality measurements collected,
  and volume of groundwater pumped/purged from the well.
- Chain-of-Custody Form (see SOP AD-02) The COC form must be completed for all samples collected and analyzed in the course of a project. COC documentation will commence upon sample collection and will include information for each sample: unique sample identification number (ID), sample collection date (day, month, and year) and time, type and number of sample containers, preservation data, and sample analysis. The form also lists client information, the EnSafe project manager, field sampler(s), shipping/delivery methods, and the job number/purchase order number/release number (information specific to the contract with the analytical laboratory). Additional information includes the date/time that custody is released by EnSafe, the name/signature of the employee releasing custody of the samples, and the name/signature of the laboratory employee accepting custody.

The signature of any individual on the COC form is that person's assertion that they personally handled or processed the samples identified on the record.

Special instructions for the contracted laboratory can also be listed on the COC form. The individual(s) collecting the samples will complete a COC form, which will accompany each sample shipment to document the transfer of custody from the time and point of collection until delivery to the laboratory for analysis. Copies of COC forms are kept by the sample team leader and given to the project manager when the field effort is completed.

 Sample Label (See SOP AD-02) — The sample label is used to identify a collected sample. The sample label shall be filled out with permanent ink and contain the site/project name, unique sample ID, type(s) of analysis to be performed, date/time of collection, sample preservative, and names or initials of the field personnel who collected the sample.

If sample IDs are known in advance of sample collection, sample labels may be prepared in advance, with the date and time of collection and the names of field personnel added at the time of collection. Label information can be pre-printed electronically or filled out legibly by hand. Field personnel shall correctly fill out sample labels and attach them to the appropriate sample containers at the time of collection. Care will be taken to ensure that water or soil on the outside of the container does not interfere with adhesion of the label or legibility of the sample label information.



Chain-of-Custody Seal (See SOP AD-02) — The COC seal is used to ensure that the
collected samples are not tampered with or disturbed during handling and shipment. All
sample shipping coolers should be sealed with COC seals prior to shipment to the analytical
laboratory. Some projects may require that COC seals be placed on individual sample
containers.

# **Documentation of Equipment Maintenance**

Log all maintenance and repair performed for each instrument unit, including routine cleaning procedures, corrective actions performed during calibrations or verifications, and solution or parts replacement for instrument probes. The following information shall be recorded or retained regarding equipment maintenance:

- The calendar date of the procedures performed.
- Names of personnel performing the maintenance or repair tasks.
- Malfunctions necessitating repair or service.
- Identity of specific instrumentation in the documentation with a unique description or code for each instrument unit employed. This may include a manufacturer name, model number, serial number, inventory number, etc.
- Vendor service records for all affected instruments.

For rental equipment, document or retain the following information:

- Rental date(s)
- Equipment type, model, inventory number, or other description
- Manufacturer's operation and maintenance instructions.

#### **Instrument or Method Calibration**

Document the acceptable calibration data for the instruments or other measuring systems used during field sample collection, tests, and analyses in the field logbook or on an acceptable field form. The following information shall be recorded regarding standards and reagents used for calibration, verification, and sample measurements.

- Note the date of receipt, the expiration date, and the date of first use (if known) for all standards and reagents.
- Document acceptable verification of any standard used after its expiration date.
- Record the concentration or other value for the standard in the appropriate measurement units.
- Note vendor catalog number and description for preformulated solutions as well as for neat liquids and powder standards.



- Retain vendor assay specifications for standards as part of the calibration record.
- Record the grade of standard or reagent used.

#### Field Instrument Calibration Documentation

- Document acceptable calibration and calibration verification for each instrument unit and field test or analysis, linking this record with affected sample measurements.
- Retain vendor certifications of all factory-calibrated instrumentation.
- Designate the identity of specific instrumentation with a unique description or code for each instrument unit used.
- Record the manufacturer name, model number, and identifying number (e.g., serial number) for each instrument unit.
- Record the time and date of all initial calibrations and all calibration verifications.
- Record the instrument reading (value in appropriate measurement units) of all calibration verifications.
- Record the name of the analyst(s) performing the calibration or verification.
- Document the specific standards used to calibrate or verify the instrument or field test with the following information:
  - Type of standard or standard name (e.g., pH buffer)
  - Value of standard, including correct units (e.g., pH = 7.0 SU)
- Retain manufacturers' instrument specifications.
- Document whether successful initial calibration occurred.
- Document whether each calibration verification passed or failed.
- Document any corrective actions taken to modify instrument performance.
- Document date and time of any corrective actions.
- Note any discontinuation of use of an instrument due to calibration failure.
- Describe or cite the specific calibration or verification procedure performed (e.g., FDEP SOP or internal SOP).

# **Sample Identification**

• Label or tag each sample container with a unique field identification number that adequately distinguishes each sample according to the following criteria. The code must adequately



link the sample container with the information about the sample in the permanent field record.

- Link the unique field identification number to the sample source or sampling point identification, the date of sample collection, the time of sample collection (for maximum holding times equal to or less than 48 hours), the selected analyte(s), and the preservation technique.
- Quality control (QC) samples such as duplicate samples, other replicate samples, and split samples – collected from the same sample source or sampling point on the same date and at the same time must be identified and labeled or tagged with different field identification numbers if the identical sample collection procedures are used for the QC samples and the QC samples are collected for the same analyte or group of analytes.
- Samples collected from the same sample source or sampling point on the same date and at
  the same time must be identified and labeled with different field identification numbers if
  more than one sample collection technique is used to collect samples for the same analyte
  or group of analytes. For example, if samples for metals analysis are collected using a
  bailer and a pump, the bailer sample must be labeled to distinguish it from the pump
  sample.
- The unique field identification number and any other information included on the container label or tag must be sufficient for the analyzing laboratory to independently determine the sample collection date, the sample collection time (for maximum holding times less than 48 hours), the sample preservation, and the analytical tests to be performed on each container or group of containers.
- Attach the label or tag so that it does not contact any portion of the sample when it is removed or poured from the container.
- Record the unique field identification number on all other documentation associated with the specific sample container or group of containers.

# **Sample Documentation**

During collection of each environmental sample, the following information and data, at a minimum, must be recorded in the field logbook or on the appropriate field forms:

- Field sampling equipment used
- Field analytical equipment and other equipment used for physical measurements
- Calculations, field analytical results, calibration data for field sampling, and physical measurement (e.g., total well depth, static water level depth, length of water column, presence of accumulated silt or free-phase contaminants)
- Type of sample (e.g., grab, composite)



- Date and time using 24-hour clock of sample collection
- Description and/or maps/sketches of the sample location as necessary for accurate identification
- Sample description (as appropriate), preservation techniques, laboratory analytical methods for which the sample is being collected, and types of containers used to hold the sample
- The names of field personnel collecting the sample and present during sampling
- Weather conditions or anthropogenic influences (e.g., car exhaust fumes) present during sample collection that may potentially influence laboratory analysis of that sample

# Sample Chain-of-Custody Form

Transmit the following information to the analytical laboratory or other receiving party. Link transmittal records with a given project and retain all transmittal records.

- Site name and address; alternatively, a client code is acceptable if samples are considered sensitive information and if the field records clearly trace the code to a specific site and address.
- Date and time of sample collection.
- Name of sampler responsible for sample transmittal.
- Unique field identification numbers for each sample container.
- Total number of samples
- Required analyses
- Preservation protocol
- Comments about sample or sample conditions
- Identification of common carrier (e.g., UPS, FedEx, DHL) if used

# **Sample Transport**

- If shipping COC forms in the transport containers with the samples, place the forms in a waterproof enclosure and seal.
- All shipping coolers should be sealed with COC seals before shipment to the laboratory.
- Seal shipping containers with strapping tape.
- Keep all shipping bills from common carriers with archived transmittal records.



• If the same party collects, packs, and delivers the samples to the laboratory, custody seals are not needed on the shipping container.

#### **Decontamination Documentation**

Document all cleaning procedures by stepwise description or cite the Field Decontamination SOP, FC-01. Record the date of cleaning. If items are cleaned in the field during sampling activities for a site, document the date and time when the equipment was cleaned. Link this information with the site and the cleaning location at the site.

Retain or make accessible any certificates of cleanliness issued by vendors supplying cleaned equipment or sample containers. Retain from the vendor or document for internal cleaning the following information for sample containers, as applicable:

- · Packing slip and cleanliness certificates from vendor
- Container types and intended uses
- Lot numbers or other designations for groups of containers cleaned together using the same reagents and procedures
- Dates of cleaning
- Cleaning procedures or reference to internal cleaning SOPs
- Cleaning personnel names
- Results of QC analyses associated with container lots
- Comments about problems or other information associated with container lots

# **Documentation for Reagents and other Chemicals**

Keep a record of the lot numbers and inclusive dates of use of all reagents, detergents, solvents, and other chemicals used for cleaning or sample preservation.

#### 3.2 Electronic Documentation

# **Retention of Automatic Data Recording Products**

For data not directly read from the instrument display and manually recorded, retain all products or outputs from automatic data recording devices, such as strip chart recorders, integrators, data loggers, field measurement devices, and computers. Store records in electronic, magnetic, optical, or paper form, as appropriate.

Retain all original raw output data. Ensure these data are archived prior to subsequent reduction or other manipulation of the data. Identify output records as to purpose, analysis date and time, field sample identification number, etc. Maintain unequivocal linkage with the associated sample, other data source, or measured medium, and the specific instrument used to make the measurement.



# **Electronic Data Security**

Control levels of access to electronic data systems as necessary to maintain system security and to prevent unauthorized data editing. Do not alter raw instrumentation data or original manual data records in any fashion without retaining the original raw data. Maintain secure computer networks and appropriate virus protection for each system design.

# **Electronic Data Storage and Documentation**

Store all electronic, magnetic, and optical media for easy retrieval. Ensure that all records can be printed to paper if needed for audit or verification purposes. If the documentation archive may become unreadable due to obsolescence of a particular technology, retain a paper archive of the data or transfer to other suitable media. For easy retrieval of records, link all stored data to the associated sample or other data source. Back up all data at a copy rate commensurate with the level of vulnerability of the data. Consider replicating all original data as soon as possible after origination.

# **Software Verification**

Ensure that any software used to perform automatic calculations conforms to required formulas or protocols. Document all software problems and their resolution in detail if the problems have irretrievably affected data records or linkage. Record the calendar date, time, responsible personnel, and relevant technical details of all affected data and software files. Note all software changes, updates, installations, etc.

# **Protection of Equipment and Storage Media**

Place stationary computers, instrumentation, and peripheral devices in locations of controlled temperature and humidity and away from areas where the potential for fluid leaks, fire, falling objects, or other hazards may exist. In the field, protect portable equipment from weather, excessive heat or freezing, storage in closed vehicles, spillage from reagents and samples, etc.

Protect storage media from deteriorating conditions such as temperature, humidity, magnetic fields, or other environmental hazards.

# 3.3 Documentation Using Other Media

Store media such as photographs, photographic negatives, microfilm, videotape, etc., under conditions generally prescribed for those media by manufacturers and conducive to long-term storage and protection from deterioration.

For each photograph taken a site, the following information shall be recorded in the field logbook:

- Time, date (if not automatically stamped), location, direction, and weather conditions (if necessary)
- Description of subject
- Name of photographer

# 3.4 Sample Analysis (Not Applicable)



#### 4.0 DATA ACQUISITION, CALCULATIONS, AND DATA REDUCTION

Any calculations or measurements performed in the field shall be appropriately documented in the field logbook or on field forms.

# 5.0 DATA/RECORDS MANAGEMENT

At the completion of a field effort, all logbooks and field forms shall be given to the Project Manager and will be maintained as a part of the project file. A copy of the logbooks and field forms may be maintained by the field person in case the documents are lost, or the Project Manager has questions.

#### 6.0 QUALITY CONTROL AND QUALITY ASSURANCE

At the conclusion of field work, all field notes or project documentation should, at a minimum, be reviewed for accuracy, SOP deviations, and completeness. If practical, field documentation should be reviewed daily during extended field activities, as frequent reviews may help identify potential problems and provide opportunities to implement corrective action measures during the field event.

#### 7.0 NONCONFORMANCE AND CORRECTIVE ACTION

It is imperative that field personnel document field activities in accordance with the instructions in this SOP and any site-specific SAP or work plan requirements. Improper field documentation can lead to questionable or invalid analytical sample results, which may necessitate repeated sampling efforts.

#### 8.0 REFERENCES

Florida Department of Environmental Protection. DEP-SOP-001/01, FD 1000 Documentation Procedures. Effective Date January 2017. Retrieved from https://floridadep.gov/dear/quality-assurance/content/dep-sops

United States Environmental Protection Agency, Region 4. *Logbooks, SESDPROC-010-R5*. Effective Date May 30, 2013. Retrieved from https://www.epa.gov/sites/production/files/2015-06/documents/Logbooks.pdf.

Attachments — Forms, Checklists, and Data Sheets (None)

Author	Reviewer(s)	Revisions (Technical or Editorial)
Phil Hardy	Allison Harris	Revision 0 — April 2006 (Initial Issue)
	Ben Brantley	Revision 1 – September 2019
	Holly Brauer	Revision 2 – May 2020